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OVERVIEW OF QUALITOLOGY

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LIST OF NOTATIONS

A – set of abstract objects,

b – absolute measure of similarity of states of quantitative feature with absolute or uniform measurement scale,

b_w – relative measure of similarity of states of quantitative feature with absolute or uniform measurement scale,

c – feature,

c^p – object feature,

$\mathbf{C}_s$ – set of stimuli and motives,

D – set of acceptable solutions to a qualitative decision-making problem,

e_j – quotient indicator of the economic effectiveness of qualitative decision,

e_j' – differential indicator of the economic effectiveness of qualitative decision,

$\mathbf{E}_i$ – set of economic categories,

F(c) – property of features belonging to objects,

F(s) – property of states of features belonging to objects,

F(**J**) – property of quality belonging to objects,

F(**S**) – property of states of quality belonging to objects,

F_c – function of quality for features,

F_d – diagnostic function,

$F_{\mathbf{J}}$ – function of quality for quality,

F_k – classification function assigning qualitative categories to classes,

F_p – classification function assigning classes to objects,

F_s – semantic function,

F_t – transformation function,

F_z – quality management function,

F_{ji} – function of value of the ith qualitative category for the jth feature of value,

F_{pr} – design function,

F_{sm} – stimulating and motivating function,

F_{dec} – decision-making function,

g_n – relative measure of similarity of object quality,

g_{bn} – absolute measure of similarity of object quality,

G_n – relative measure of similarity of states of object quality,

G_{bn} – absolute measure of similarity of states of object quality,

$\mathbf{J}$ – quality,

$\mathbf{J}_i$ – individual quality,

$\mathbf{J}_p$ – level of quality,

$\mathbf{J}_r$ – fuzzy quality,

$\mathbf{J}_s$ – state of quality,

$\mathbf{J}_w$ – common quality,

$\mathbf{J}_s$ – fuzzy state of quality,

$\mathbf{J}_{sdl}$ – deterministic and random state of quality,

$\mathbf{J}^p$ – object quality,

$\mathbf{J}^{\mathbf{W}}$ – set of object components quality,

$\mathbf{J}^{\mathbf{Z}}$ – set of quality of object's environment components,

$\mathbf{J}^{np}$ – non-evaluated quality of object,

$\mathbf{J}^{we}$ – input function quality,

$\mathbf{J}^{we}$ – output function quality,

$\mathbf{J}^{wp}$ – evaluated quality of object,

$\mathbf{J}^{sz}$ – quality of management signals,

$\mathbf{J}^{zs}$ – quality of managed subsystem,

$\mathbf{J}_s^p$ – state of object quality,

$\mathbf{J}^{(1,2)}$ – difference in quality of object 1 against object 2,

$\mathbf{J}^{(2,1)}$ – difference in quality of object 2 against object 1,

$\mathbf{J}^{(1,2-2,+1)}$ – difference in quality between objects 1 and 2,

$\mathbf{J}^{(x,n)}$ – difference in quality of object x against quality of objects from set of n-cardinality,

$\mathbf{J}_s^{(1,2)}$ – difference in state of quality of object 1 against the state of quality of object 2,

$\mathbf{J}_s^{(2,1)}$ – difference in state of quality of object 2 against the state of quality of object 1,

$\mathbf{J}_s^{(1,2-2,1)}$ – difference in states of quality between objects 1 and 2,

$\mathbf{J}_s^{(x,n)}$ – difference in state of quality of object x against states of quality of objects in set of n-cardinality,

$\mathbf{J}_{wł}^{p}$ – qualitative proper synergy effect, expressed by a set of features,

$\mathbf{J}_{swł}^{p}$ – qualitative proper synergy effect, expressed by a set of states of features,

k_i – ith qualitative category,

k_{si} – state of ith qualitative category,

k_i^w – ith evaluated qualitative category,

$\mathbf{K}_i$ – set of states of the ith qualitative category,

$\mathbf{K}_j$ – set of qualitative categories,

$\mathbf{K}_l$ – set of classes in object classification,

$\mathbf{K}_{dec}$ – set of qualitative decisions,

L – set of subjects,

M – set of material objects,

O – object,

p – subject,

p_c – level of quantitative features of absolute or uniform measurement scale,

p_{cw} – intensity of quantitative features of absolute or uniform measurement scale,

p_{ki} – intensity of ith criterion of quality comprehensiveness,

p_{wsr} – mean intensity of quantitative features of absolute or uniform measurement scales,

P – predicate,

P – set of objects,

$\mathbf{P}_c$ – material scope of feature,

$\mathbf{P}_s$ – material scope of state of feature,

$\mathbf{P}_\mathbf{J}$ – material scope of quality,

$\mathbf{P}_\mathbf{S}$ – material scope of state of quality,

$\mathbf{P}_{pr}$ – set of designed objects,

R – relation,

R_w – evaluating relation,
R_{wz} – evaluating relations according to model,
$\mathbf{R}$ – matrix of relations,
$\mathbf{R_J}$ – family of sets of features,
$\mathbf{R}_{je}$ – set of relations between qualitative and economic categories,
$\mathbf{R}_{wew}$ – set of internal relations,
$\mathbf{R}_{zew}$ – set of external relations,
$\mathbf{R_s}$ – family of sets of states of features,
s – state of feature,
s_b – base state of feature,
s_{min} – minimum state of quantitative feature,
s_{max} – maximum state of quantitative feature,
s_{opt} – optimum state of feature,
$\mathbf{S}$ – set of states of feature,
$\mathbf{S}_m$ – set of possible states of feature,
$\mathbf{S}_r$ – set of actual states of feature,
S_{ej} – economic stimulating variable,
t – tolerance in stating the identicalness of the states of quantitative feature of absolute or uniform measurement scale,
T_c – frequency of changes in quality,
T_s – frequency of changes in state of quality,
w – feature of value,
w_j – jth feature of value,
$\mathbf{W}_j$ – set of states of jth feature of value,
W_{k1} – sum of analytical values of qualitative categories,
W_{k2} – arithmetic mean of analytical values of qualitative categories,
$\mathbf{Z}$ – set of management signals,
$\mathbf{Z}_s$ – set of linguistic signs,
μ_J – function of quality membership,
μ_p – function of probability of state of quality,
μ_p – function of membership of state of quality.

Introduction

The emergence and beginnings of any scientific discipline are connected with a question whether there are reasonable premises and objective, favourable conditions for the creation and development of a new system of knowledge. Therefore, in line with the fundamental thesis this book attempts to justify, it is necessary and possible to isolate **qualitology** as studies of quality on the basis of the existing achievements of science and knowledge derived from practice. This difficult academic task is accompanied with the author's conviction of its purposefulness and anticipated benefits. These benefits belong to the area of the most general instruments of learning and shaping reality by man and are theoretical and engineering in nature[1].

The starting point for the creation of qualitology is good, although extremely complex and difficult. The **qualitative view** is a universal, fundamental, common, oldest although still current methods available to man to learn and transform reality[2]. The consequence of that is the presence of quality-related issues in all areas of human activities: theoretical and practical, design, manufacturing and use-related, individual, and social, economic, cultural, ecological and many more. The meaning of qualitative categories is strongly rooted in economic activity, in particular in manufacturing and in many scientific disciplines, especially in philosophy, economics as well as studies of organisations and management. They are also used, mostly intuitively, in common individual and social practice.

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[1] The engineering nature of the achievements of science results from the possibility of application thereof in practice, using applied science.

[2] As John R. Platt claims, many, or even most great topics in science, even in physics and chemistry, are qualitative and not quantitative in nature (after [66, p. 23]).

Another fundamental method to learn reality is the **quantitative view** which is frequently juxtaposed with the qualitative view. Therefore, an interesting question arises regarding the relationship between the qualitative and quantitative views. Is the qualitative view less excellent that the quantitative view? Is it possible to create a methodological basis for a coherent, comprehensive view of reality, combining the qualitative and quantitative perspective? The search for the answers to that question on the grounds of qualitology is also the subject of interest and research in this publication.

The consequences of the universality and the importance of the issues of quality in activities of man include considerable scientific achievements reflected in vast literature. A fundamental drawback, however, of these achievements, is the methodological diversity and considerable dispersion in many fields of science as well as disharmony between the theoretical and engineering approaches. In our times, the domination of pragmatism and utilitarianism in the approach to quality, as well as focus on quality management problems in economic activity is noticeable. Hence scientific studies of the last decades pertain most frequently to this section of qualitology, that may be named quality management engineering. Thus, the harmonious overview of the quality knowledge system presented in this work specifically stresses the need for the development of **general quality theory** which forms a methodological basis for quality engineering, including quality management engineering.

This book's title suggests a preliminary, simplified, and general concept of the creation and shape of qualitology, with a possibility of further detailed exploration and development. This is the author's original concept and is based on the results of own research and an attempt to synthesize the existing scientific achievements. As the fundamental premise in the creation of the overview of qualitology, the drive to transform the dispersed and often incoherent knowledge of quality into a quality system (quality studies) was adopted, which explains it best and eliminates differences between views of the authors, including theoreticians and practitioners. Due to the huge volume, it is impossible to describe the entire achievements in one publication, which means, inter alia, that this book only touches upon the most general issues of the theory of quality, in particular the general theory of quality. Moreover, an assumption was made that problems are worth formulating even when the solutions thereto are not exhaustively developed. This may inspire other authors to work on the development of qualitology.

In this book's structure and contents, an attempt was made to include all the elements that constitute a scientific discipline. This does not mean, however, that each of them will be sufficiently identified and developed.

Therefore, the indication of directions for further research and development of qualitology is a material value of the book. What is more, building qualitology on other methodological foundations is also possible, for example using other tools for modelling and formalisation of categories, phenomena and qualitative operations than are specified herein (e.g., systems theory, functions theory). At this point it is assumed that there is sense to any science or theory if it is an effective tool to study or shape reality.

The general structure of the book is made up of six chapters which present the overview of qualitology. The first chapter includes a practical and theoretical justification of the need to create grounds and isolation of a new scientific discipline known as qualitology. It stresses e.g., the place and meaning of quality in economic activity and the terminological difference in this respect.

The second chapter presents a concept of standard elements of the subject of qualitology, specific for each scientific discipline. They include: scope of reality that is taken into consideration in qualitology, research consideration, purpose, and instruments of research. To create a system of knowledge of quality, the important concept of the division of qualitology has also been presented.

The third chapter concentrates on the proposed terminology, covering the most important terms in qualitology. As the basis of this convention and formalisation of qualitative categories, approaches typical of the **set theory** have been adopted. The choice of terminology is supposed to assure highest possible accuracy and precision in modelling reality and interpersonal communication. Negligence and diversity in terminology are the main reasons for inconsistency in the scientific achievements and difficulties in building qualitology. The classification of features and quality is an important tool used to systematise quality-related issues.

Chapter four enumerates and describes six basic operations regarding quality: determination, systemisation, comparison, evaluation, optimisation, and management. The above operations are performed as part of the cognitive, creative, and manufacturing activities of man in a situation, wherein the system components are presented qualitatively.

Chapter five presents a breakdown and description of eleven principles of the **qualitative approach** which may be used in the processes of learning and shaping reality. The purposefulness and possibility of using this approach, as well as the already known system approach has been demonstrated. The qualitative approach is **generally methodological** in nature and may be applied in any activity and discipline, if a given subject recognises the purposefulness of the qualitative modelling of the components of reality. The discussed approach is expressed in the following principles of qualitative approach to objects[3]: qualitative mapping, anthropocentrism (humanocentrism), comprehensiveness, systematicality, synergy, kinetics, probability, evaluation, optimisation, normalisation, and economics.

Chapter six presents selected applications and functions of qualitology, in particular the general theory of quality. Many universal functions of qualitology were noticed, that may be used in other scientific disciplines and fields of practice (e.g., in mathematics, physic, chemistry, linguistics, information theory, economics, modelling, design, manufacturing). However, only a few examples regarding the following practices have been presented: modelling of objects and information function, systemisation of objects and classification function, communication and semantic function, quality of life and quality of management.

The work on the book has had a number of objectives. The dominating objective is undoubtedly academic and cognitive, expressed in the attempt to systematise and expand the knowledge of quality, in particular to organise it methodologically, adequately to the general theory of quality. Achieving this objective is, in turn, a condition for reaching the goals of quality engineering and then utilitarian and didactic goals. This book may be an inspiration for scientists and contribute to further development of qualitology. The results of theoretical research may comprise source material used in general basic education in many university courses and doctoral studies, expanding the universal cognitive perspective with the qualitative approach. The book should prove particularly useful in the education of managers handling quality management.

Finally, it is worth stressing, once more, that the contents of this book are focused on the general theory of quality. Such a solution results from the fact that this part of qualitology is not sufficiently developed. Moreover, by definition, the general theory of quality should determine the comprehensive structure of quality studies that specific theories of quality and quality engineering may belong to.

[3] The term "object" was adopted as a universal name of any component of reality.

Chapter I

PRACTICAL AND THEORETICAL PREMISES FOR THE DEVELOPMENT OF QUALITOLOGY

1.1. Practical considerations of qualitology

In order to justify the need and demonstrate that the development of qualitology is possible, it is necessary to recognise and analyse the existing circumstances, premises and factors which determine the starting point, characterised e.g., by the pattern of stimulants and destimulants of the adopted scientific assignment. Due to the enormous scope and considerable complexity, only selected characteristics of the starting condition will be specified, which pertain to the presence of quality-related issues in some areas of practical and scientific activities. Firstly, it should be stated that in common practice and social awareness, quality is usually understood as a specific **type of value**, determined by the degree of meeting the requirements of a subject by the given object, which is most frequently a product. This means that the category of quality allows, inter alia, meeting the universal need for a value-based (preferential) organisation of objects. The common interest in the issue of quality has been triggered by the needs of economic practice, which occur mainly in the areas of manufacturing, trade and use of products[1]. It is the economy which, through the creation of the

[1] Products, as artificial objects, may occur in three basic forms: **goods**, for which matter is the carrier of useful value; **services**, for which action is the carrier of useful value and **piece of work**, for which useful value is carried by information.

basis for material and spiritual being of any society, is where products of a certain quality are designed, manufactured, traded, used, and consumed. A dynamic development of empirical research of quality in the last decades may be interpreted as a manifestation and evidence of the drive to increase the effectiveness and efficiency of economy. Increasingly excellent work and its results assure a long-term progress of civilisation and boost of the **quality of life** of individuals and societies. Concurrently, the reserves triggered by the application of quality-oriented strategies allow further development, both intensive and extensive.

The rich and universal practice in the scope of an actual influence on quality in economy and other fields of activity, was not, unfortunately, accompanied by a satisfactory development of the theory of quality, despite the observed increase in the number of relevant publications. These publications are mostly engineering in nature and are devoted to current practical issues.

The importance of quality in the economy is stressed by the hypotheses regarding the relation between the quality-oriented strategy of management with the strategies of intensive and extensive development known in the history of economics. In line with this hypothesis, the strategy of extensive development is based on the category of **quantity**, and the strategy of intensive development builds on the category of **quality**.

A basic effect of using the strategy of extensive development is the **quantitative growth in production and consumption** of products known in the given time, which in consequence leads to the saturation of the market with these products. The assumption underlying this strategy is to duplicate the structural and technological quality standards which causes favourable quantitative changes in product volume. These changes are by nature of little innovativeness and demonstrate poor stimulation and use of the scientific and technological progress. Quantitative changes are relatively less interesting in cognitive terms and mainly require physical effort of workers in manufacturing operations. Quantitative increase in product volume causes a proportional increase in physical labour, consumption of natural resources and manufacturing costs. As a result, this type of strategy does not assure the desired and continuous improvement of the economic efficiency of management. The application of this strategy only in the economy would lead to, inter alia, innovation stagnation and a relatively faster depletion of natural resources.

A basic effect of the application of the strategy of intensive development is the **qualitative increase in production and consumption** of continuously improved and new products and technologies. This strategy is based on the assumption of constant increase in quality standards of products and technology and in qualitative changes, which are by nature highly innovative and strongly stimulate and use the progress in science and technology. Qualitative changes are interesting in cognitive terms and require chiefly intellectual effort. The qualitative increase in production volume results in the boost of useful value at less than proportional increase in physical labour, consumption of natural resources and manufacturing costs. As a result, this type of strategy assures the continuous improvement of the economic efficiency of management. Its application in the economy leads to, inter alia, innovation and slower depletion of natural resources.

Both development strategies are observable in parallel in the history of management, although their share in the creation of economic and civilisational progress in various places and at various times is different. Many symptoms indicate a tendency for constant growth in the share of the intensive management strategy, which means, concurrently, higher importance of the quality-oriented strategies. Many difficult problems which modern world faces (saving natural resources, environment protection, protection of life and health, world food supply, assurance of energy and more) may be solved mainly using the method of intended qualitative changes in economic activity.

Higher interest in the issue of quality manifested over the last decades of economic activity is affected by the combination of many tendencies, circumstances, and achievements. The most important of the above include [17, p. 9]:

- common awareness of the growing importance of quality in competitive struggle on markets (qualitative competition) and the discovery of the possibility to regard product quality as a specific "commodity", valued in line with the economic market valuation mechanism,
- need to improve the quality of work, processes, and products as an improvement of the economic management efficiency and the achievement of other purposes of the organisation,
- fast quantitative growth in production and welfare of people as well as the saturation of markets with standard products, which boosts the quality-related requirements of customers and diversification of product range,
- need for environmental protection and savings in natural resources, resulting in, inter alia, national and transnational legislative measures in this respect,

- dynamic progress in science and technology, development of sciences, universal and exclusive innovation – e.g., IT revolution, genetic engineering, cosmonautics, nano-technology, material engineering,
- the refined, high requirements of modern industries (rocket, nuclear, space, defence, electronic, telecommunication industry, etc.) which are the driving forces behind progress,
- spectacular successes of businesses and economies which use the intensive, quality-centered development strategies (e.g., Japanese businesses),
- growing pressure from many organisations (consumer, environmental protection, certification, political, state etc.) regarding the continuous improvement of the quality of life of businesses as well as product quality.

The quality awards granted in many countries constitute a prestigious, marketing and publicity-related factor which motivates organisations to employ quality-oriented strategies. The first quality award, the Deming Prize, was established in 1951 in Japan. In 1987, in the United States, the national Malcolm Balridge award was established, which recognised the main achievements in customer service quality. For Western European enterprises, which recorded the largest successes in terms of complex quality management, the European Quality Award was established in 1991. Since 1995 the annual, prestigious Polish Quality Award has been granted, which builds on the solutions of the European Quality Award and takes into consideration the scientific and practical achievements in the development of quality management. Quality awards include also the TerazPolska award [17, p. 10].

Tasks related to the promotion, protection, provision, education, standardisation as well as many other projects concerning quality are carried by numerous domestic and international organisations, e.g., the European Organisation for Quality (EOQ), the Japanese Union of Scientists and Engineers (JUSE), the American Society for Quality (ASQ), International Standardisation Organisation (ISO) and the International Academy of Quality (IAQ), the Polish Centre for Testing and Certification (Polskie Centrum Badań i Certyfikacji, PCBC), Polish ISO 9000 Forum (Polskie Forum ISO 9000).

The economic pressure occurring in market economy, which results from the market self-regulation mechanism, is favourable to the quality-related trends within an enterprise. The nature of this mechanism assures, on a universal scale, the stimulating **binding of qualitative categories with economic ones**. In a competitive market economy, success or failure of an enterprise depend on the quality of operation, in particular in the quality of technology and offered products. The quality of products and customer service are the primary factors that affect revenues, profits, market standing and the success of any manufacturer. Qualitative competition is also the market driving force that creates a system of quality-oriented measures in enterprises.

The qualitative effects in enterprises result primarily from the management processes, and then from the design and manufacturing processes. Therefore, the role of managers (executive staff at all organisational governance levels) is of particular significance. They should demonstrate professional qualifications in management and be responsible for the achieved results, both in quantitative and qualitative terms. When exercising the management and decision-making functions, they basically and universally impact the course and effect of most measures undertaken in an enterprise. They also build a new climate and quality-focused culture. Thus, the qualitological education of managers is necessary and very important.

The origin of the growth in the importance of quality in practical terms is well illustrated by the historical evolution of the approach to the management of manufacturing organisations over the last centuries. Five basic periods and business orientations may be distinguished, which occur at various times in individual parts of the world.

The earliest period was dominated by the so-called production orientation, which is characterised by the drive to making the most of the manufacturing potential through boosting the labour efficiency and production scale. Product quality was at this point a natural, relatively stable standard the achievement of which was necessary and obvious and depended on technology and technical control.

The growing problems in the sales of mass-manufactured standard products of unimproved quality were accompanied by sales-oriented management. The extended sales force was supposed to ensure, through a pumping mechanism, the flow of products from the manufacturer to the purchaser. A problem of the customer service quality emerged, as well as the need for qualitative diversification of products in order to facilitate sales.

The next phase in the quality-focused development was product orientation, consisting in the dominating role of product quality and qualitative diversification of product range in reaching the market and economic goals by an enterprise.

A material breakthrough in the approach to quality occurred during the marketing orientation period (including customer and market orientation). The manufacturers became focused on studying and stimulating, and then satisfying, the needs of customers and users. Intensive competition and the properties of the buyer's market resulted in the fact that product quality became the main indicator of market position and an economic condition for the success of manufacturers. In this case, even a developed technical control dominated by passive functions became insufficient and the quality management service was created, with the majority of active functions [41, p. 13-17].

Over the last decades, in more developed countries, quality-orientation emerged, which consisted in the implementation of quality management system and the application of the Total Quality Management method (TQM). This orientation is characterised by a complex approach to the issue of quality in organisation and its surroundings [10, 21, 11, 12, 22]. This complexity results from a legitimate assumption that the quality of finished products is determined by the operation of all subsystems in a manufacturing organisation. In the current phase of the development of Total Quality Management method, its assumptions and practical hints are sufficiently worded, and the theoretical foundations need to be completed.

There is no reason why the logic of thinking and actions related to quality applied in enterprises should not be extended over all other types of organisations and to recognise the need and role of quality management also in their operation. Quality management is the task of the executive staff in any organisation. The achievement of qualitative goals set is possible when quality is regarded as the primary goal, tool, and object of management. Therefore, the starting task for managers is to design and implement, in an organisation, an effective quality management system that is capable of performing roles and reaching quality goals. This system may occur in various organisational forms and have different scope of impact. In its most developed form, it covers the entire management system in an organisation. Therefore, there is the need for the quality management methodology in the operation of various types of organisations. The development and publishing of a series of ISO 9000 standards regarding quality assurance systems in business organisations in 1987 was a response to that need. Then these standards were periodically modified and published as "quality management systems".

The methodological correctness of quality management in practice depends directly on the progress in the development of qualitology, in particular on the progress in the development of quality management theory and engineering. A situation wherein the development of science does not keep pace with the needs of practice in such an important field as quality management is obviously a hindrance to progress in the broadly understood quality of human life. Concurrently, such a situation causes that, in terms of qualitative practice, organisations are forced to use the costly trial and error method and incoherent, fragmentary actions that impair effectiveness.

To sum up, it may be concluded that there is a series of material practical premises for the creation and development of qualitology, as the issue of quality is materially present in all areas of human activity. One may venture to pose a thesis that the development of qualitology considerably determines the multi-directional qualitative progress which, in turn, is the principal determinant of the civilisational development expressed by the quality of human life.

1.2. Theoretical sources of qualitology

Currently, qualitology should be treated as a specific source of knowledge of quality, which requires a comprehensive approach, organisation, and further development. This knowledge is relatively better developed in the area of quality engineering, and, to a lesser extent – in the area of quality theory. In the early 1970s, Romuald Kolman [27] proposed to use the name "qualitology" to describe all that was achieved through academic study and in theory of qualitative modelling and engineering of the methodology of practical qualitative problem solving. He also presented some solutions regarding the general division and systemisation of the issues of qualitology.

The pioneer solutions and concepts of R. Kolman, which also suggest the directions of further development of qualitology due to e.g., the originality and difficult terminology, have not found many advocates and continuators. The name of the discipline itself, although logical, substantially, and etymologically grounded and with accurate promotional terms, is not commonly used. One may believe that the basic reasons for this include the lack of awareness and the need for a scientific research and for the development of cardinal and universal issues regarding quality, considerable diversity and dispersion of literature which comprises many quality-related motives as well as emerging terminological problems. Only few, and mostly Polish scholars see this deficit and the need to develop a general theory of quality within qualitology. They help fill this gap with their studies [6, 7, 8, 9, 27, 28, 29, 30, 38, 39]. R. Kolman and T. Borys [7, 29] hold considerable achievements in this respect.

The origin of the to-date, particularly engineering-related, achievements in qualitology is linked with the circumstances of the occurrence of technical product control in manufacturing organisations. Therefore, qualitology stems from practice, and thus far to practice it has been subject. In line with the progress and increase in sophistication of the manufacturing processes, products, trade and use, and as the requirements constantly increased, the item of qualitative categories systematically became more grounded and the methodological instruments for the control of quality in economic entities developed. This process is continued even now and results in dramatic increase in the number of publications, mostly pragmatic in nature. The to-date publications regarding qualitology are dominated by specialists representing fields which have the strongest links with quality management in manufacturing organisations, such as technical, economic, psycho-sociological, managerial, legal, and mathematical.

The long-term domination of pragmatism and disproportional utilitarianism had many positive results, but it also was the cause underlying many drawbacks and disharmonious development of qualitology. The major drawbacks occurring in the past include [28, p. 16]:

- reduction of the object of qualitological research to products and manufacturing processes,
- domination of a one-sided approach to quality which refers to the interpretation of useful value of products in economics as a degree to which requirements are met by the properties of a specific product,
- dispersion, ungrounded diversity, and industry-oriented research approaches which led, inter alia, to the insularity of the developed models, methods, and solutions to quality-related problems,
- terminological disorder resulting from the occurrence of many diverse, often industry-related, definitions of basic qualitative terms,
- insufficient development of the general and specific theories of quality which are the basis for, inter alia, terminological bridges which facilitate communication and integration of theory, engineering, and practice in the scope of quality.

The state, in which many diverse and often mutually exclusive theoretical models stemming from the different perceptions of qualitative terms, specific nature of industry-related objects of research and from diverse professional specialisations of researchers, results in scientific inconsistency and reduces its practical effectiveness. There are many premises which indicate that currently we deal with a situation wherein the utilitarian models and solutions influencing the quality of practical objects are ahead of the desired generalisations expressed in the cognitive, systematising, and methodological functions of the theory of quality.

The analysis of the abundant literature, research and observations clearly shows that qualitative categories are increasingly often becoming objects of scientific research although it is difficult to conclude that qualitology, as the science of quality, has specific grounds and position among other scientific disciplines. Moreover, there is not clearly and explicitly defined central category i.e., the category of **quality**, with reference to known philosophical directions and doctrines. On the other hand, the terminological and managerial standard of the issues of quality contained in the ISO 9000 standards is gaining importance.

In the past, the researchers of quality focused on manufacturing enterprises and the industrial products as well as manufacturing technologies analysed in the context of technical control processes were the primary object of study. Currently, we are witnessing a breakthrough, favourable for the development of qualitology, which consists in the expansion of the object of study onto products, processes, actions and systems taking into account the growing spectrum of research aspects, and not only the technical control.

This breakthrough stresses and intensifies the phenomenon of the interdisciplinarity of qualitology which consists in the possibility and purposefulness of using the methodological achievements and terminology of many scientific disciplines regarded as supporting disciplines. Disciplines supporting the qualitological research include, inter alia (see [29, p. 26-27]):

- **philosophy**, which is the source of terminology and the basis for formulating and solving the fundamental issues of qualitology,
- **mathematics**, which provides methods to formalise, transform and for mathematical modelling in qualitology,
- **praxeology**, which gives qualitology the qualitative aspect of efficient (effective and economical) operation,
- **cybernetics**, which makes it possible to build quality control systems,
- **economic sciences**, which deliver methods to study quality in the economic aspect,
- **science of organisations and management**, which support the design, implementation and functioning of the quality management systems in organisations,
- **psychology**, which allows the recognition of the system of human needs, preferences, requirements, goals, behaviours, and motivation in relation to the quality of the surrounding reality,
- **metrology**, which supports qualitology in terms of quantitative depiction of quality, in particular the quantitative determination of the features of objects and requirements of subjects,
- **systems theory and engineering**, which allows a systemic approach to quality of objects and their surroundings,
- **marketing**, which allows a market-oriented recognition of quality,
- **sozology**, which supports a pro-environmental impact on the quality of artificial objects,
- **design engineering**, which allow the introduction of the theory and methodology of design to the issue of shaping quality,

- **technical sciences**, assuring field-based specification in the use of technical object quality,
- **medical sciences**, assuring field-based specification in the use of human health quality,
- **ergonomics**, assuring field-based specification in the use of the quality of working environment,
- **legal theory**, allowing the recognition of the issues of quality in the system of law,
- **computer science**, assuring modern instruments to handle the quality-related information.

Apart from many benefits resulting from the interdisciplinarity, there is also a series of threats to the consistency of qualitology, in particular considering the unsatisfactory state of the general theory of quality and with absence of terminological order.

Taking the above premises into consideration, one may conclude that currently the primary object of qualitological research comprises comprehensively perceived organisations, enterprises in particular. The object of research defined in this manner covers the following issues and directions for qualitological studies [17, p. 17-18]:

1. **Determination, measurement, evaluation, and optimisation of quality**. This direction of research results from the pursuit of meeting, in cognitive and practical terms, the postulate of explicitness, accuracy as well as purposefulness and rationality in handling quality. Researchers draw special attention to the issue of analytical and synthetic indicators in the processes of evaluation and optimisation of product quality. This area shows perhaps the largest, in the field of qualitology, diversity in the proposed concepts and solutions. Also attempts have been made to identify and organise features in a universal order (properties, attributes, traits, virtues, characteristics).
2. **Organisation of the quality management unit (control, assurance, monitoring)** in enterprises, recognised, inter alia, in the aspects of system, structure, function, process, hierarchy, resource, competence, decision-making and information. The works regarding these issues employ mainly the achievements of the science of organisation and management.
3. **Methodology of qualitative decision-making**. Qualitative decisions are made mainly in the design and management processes and pertain primarily to the quality of products and technology as well as the qualitative diversification of product range. In the decision-making process, the quality evaluation and optimisation methods are used, as well as the achievements

of many auxiliary disciplines and scientific categories such as: economic efficiency evaluation, accounting, structure optimisation theory, marketing, mathematical programming, and decision-making theory.

4. **Economic and psychological methods of stimulating** organisational units and employees, resulting in the development of a pro-quality stimulation system and, further on, a pro-quality incentive system. In this group the so-called fault-free systems of work (e.g., *zero-defects*) may be distinguished continuous quality improvement (e.g., quality circles, *kaizen*) remuneration systems, internalised settlement and price fixing methods as well as some regulatory solutions regarding e.g., the protection of customers, competition, natural environment etc.
5. **Adaptation and application of mathematical statistics methods** in predicting, design, manufacturing, and control of the quality of products, means of production and technological processes. Particularly rich literature on the statistical quality control methods (SQCM) and statistical process control (SPC).
6. **Techniques applied in the development and diagnosis of quality** of objects and processes. They may include techniques of measurement (metrological techniques), reliability tests, information processing and communication, events recording (e.g., quality costs) and technical diagnostics. Mainly the achievements of technical sciences are used in works on these issues. These techniques are adequate for the individual areas of operation.
7. **Methods of qualification, approval, certification, and standardisation of quality**. This direction of research is related to the rationalisation of operation and quality-oriented stimulation of business organisations. The indicated methods are used most frequently in the scheme of system regulations, e.g., in order to make the cooperation or business contacts more efficient, labelling goods with quality and control marks related to granting quality certificates and awards and reasonable reduction of quality diversity.
8. **Research of the so-called quality costs**. This direction in research stems from the need to determine the economic efficiency and optimisation of quality-related solutions and decisions. The purpose thereof is to identify, structuralise, record, and develop methods to use quality costs in enterprises.
9. **Development of an integrated quality management system**. This field of research takes into account a common tendency for the integration of the management systems, supported by a quick development of IT and communication techniques. The integration consists in the

expansion of the scope and increase in the cohesion of quality management systems in enterprises. The publication of ISO 14000 and 18000 standards regarding environmental protection and of occupational health and safety was a particular impulse for such actions.

10. **Development of the Total Quality Management system (TQM)**. This scope of research includes the needs of the last and most excellent stage of the development of quality management. Its characteristic indicator was that the scope of quality management covered the entire organisation comprising many structures, all functions were taken into account and the state-of-the-art management methods were used, the interests of all stakeholders were seen to, and the pursuit of excellence in all areas of the operation of organisation was recognised.

The above directions of research belong mainly to the area of quality engineering, however, the search for theoretical sources of general quality theory should start with philosophy.

The philosophical sources of qualitology are rooted in the scheme of basic branches of philosophy i.e., **ontology** which comprises theories of the way of existence and structure of reality, **epistemology** which consists of theories of objects, contents, limits, methods, criteria and the authenticity of human cognition and **axiology** which presents theories of values and objects, limits, methods and evaluation criteria, and, in particular, ethics, aesthetics, social philosophy, and philosophical anthropology [23, p. 26-30]. The category of quality is present in the centuries' worth of philosophical achievements and ranks high in most schools, directions, and theories of philosophy. It is impossible to enumerate all philosophical views of quality, some of them, however, ought to be referred to [6, 23, 24, 36, 38, 46, 51, 52, 62]. The category of quality first appeared in *Symposion* of Plato (427-347 B.C.), the creator of objective idealism, under the Greek term of ***poiotes***. In this philosophical system the material world was an imperfect reflection of real and objectively existing, perfect ideas (models). The term of quality, referred to specific things, meant the degree to which they reached perfection. In this context, progress in the world of things consists in the continuous getting closer of things to the perfect ideas, which equals the increase in their quality [62, p. 73-83]. It is worth noting that such an understanding of quality is based on stressing the axiological aspect and coincides with the currently dominant understanding of quality in socio-economic practice, as a degree of meeting requirements by the traits of objects. Traits describe a specific object and requirements pertain to the subject, whereas together they determine the relative and subjective excellence of object [17, p. 20].

On the other hand, Aristotle (384-322 B.C.), the author of, inter alia, the theory of matter and form, in the work *Categorie*, included quality in the set of ten most general categories of description and cognition of substance i.e., what is being determined. Other categories include: quantity, time, place, relation, position, state, disposal (ownership), activity (action), being subject to activities (experiencing) [62, p. 84-95]. He expressed sense of quality as a **collection of peculiar features distinguishing a given object from other object of the same kind**. Such understanding of quality is based on stressing the epistemological aspect and allows to conclude that "a thing is the thing that exists". Quality, presented in this manner is a partial i.e., fragmentary, incomplete, deliberately limited description of any object. The limited nature results from narrowing the comparative analysis of a specific object down only to other objects of the same type and from taking into account only the "distinguishing features" and omission of shared features. Therefore, such an understanding of quality does not guarantee that this term will reflect the full nature of the studied object, resulting from an exhaustive answer to question posed regarding the objects: What kind? How? [17, p. 20].

The term **qualitas** denoting quality was introduced to Latin by Cicero (Roman philosopher of the 1st century B.C.). This term meant a feature, trait, or virtue of a specific object [51, p. 15].

John Locke's (English philosopher of the 17th century, author of critical realism [46]) concept of interpretation is interesting. It presents a dualism which assumes the existence of a **primary** (objective, inherent) **quality** of things and a **secondary quality** (subjective, relative). Primary quality of things occurs in reality regardless of whether or nor it is perceived by anyone. Secondary quality is created in the mind of the subject as a result of the impact made by the primary quality on the subject's receptors and thought processes and is the function of the spiritual and physical condition. The primary quality is independent, and the secondary quality depends on the object studying the thing. A similar attitude was presented by René Descartes (Cartesius, French philosopher and mathematician of 17th century), which is symbolically confirmed by the following: "as our senses sometimes delude us, I intended to assume that nothing is such as our senses lead us to imagine" [52, p. 26].

Immanuel Kant (a German philosopher of the 18th century) presented a different position as regards the perception of quality by contesting the dual nature of quality. In his *Critique of Pure Reason* and *Prolegomena* he presents a view regarding the subjective nature of the cognition of quality and objective nature of studied reality [1]. In line with this view, quality, both primary and secondary, is subjective in nature.

The starting point of the deliberations of most philosophical directions is the universally considered, adopted order in the scope of ontological categories. One of the many proposals in this respect is reism, developed by Tadeusz Kotarbiński [32]. Reism is a theory, wherein only things (material objects) are independent beings, existing objectively and autonomously. Reism is based on materialism, the central category of which is matter, understood as objective reality, independent from any existence of another nature (as being in a universal meaning). Therefore, matter is a material for things that comprise it (these are beings in a partial meaning). Matter and thing are the only primary ontological categories in reism. It may be believed, however, that reism does not exclude the existence of subjective and non-autonomous realist, to which also quality should be assigned.

The other part of philosophy – epistemology (theory of knowledge [20]) is concerned with the potential and scope of human knowledge and its authenticity. The processes of knowledge, in which a particular role is exercised by the subject and all instruments of knowledge, help answer the cardinal and universal question: **what is the thing that exists like**? The general formula of the answer to such a question is directly related to the category of quality: **this is what the thing that exists is like**.

In materialism and reism, the attributive concept of matter lies at the source of knowledge. It is based on the epistemological category of attribute, understood as an inherent feature of matter (material trait, virtue). Attribute is not an autonomous being. The basic and inherent attributes of matter include: lengthiness in three-dimensional space, movement, indefinite existence in time, indestructibility, and divisibility. From the attributes of matter the attributes of things result, isolated due to the attribute of the divisibility of matter [17, p. 20-21].

The mechanism of separating and studying things by human beings derives from the potential of things to influence senses and create visual, auditory, gustatory, olfactory, tactile and other stimuli, as well as the observations and ideas, and thought processes. The process of isolating any thing consists in formulating the features assigned to it, which determine also its distinctiveness (individual features) and likeliness (shared features) to other things.

When considering the relation between **ontological categories of matter** and **things** and **epistemological categories of quality** and **features**, it is assumed that features and quality belong to matter and things and are not autonomous. Quality and features exist in relation with the subject of knowledge and sources of its impressions, observations, and thoughts[2]. They allow the creation, by the subject of knowledge, of **informational images (models) of reality**, which any scientific discipline is concerned with. This specific item of the **subject of knowledge** is related to all epistemological categories functioning in the subject's consciousness which for a material of thought processes and the creative consequences thereof, as well as processes of communication using specific languages.

The third division of philosophy is axiology, which deals with the existence of systems of values reflecting the active attitude of a human being to the surrounding reality and themselves. The primary function of axiology is the recognition of the existing and the creation and verification of new systems of values. A material type of the relation between human beings and the things and other people interacting with them may be expressed using the **category of value**. In a constructive activity (creative and manufacturing), human beings form reality in line with the adopted system of values and suggested models, and then control their effectiveness. The result of this control, in Plato's understanding, is called quality, and according to Aristotle's concept, it is one of the material features that allow the study of dissimilarity of objects due to their value. It is worth noting that quality, as understood by Plato, may be one of these values. An important, from the qualitological viewpoint, conclusion may be drawn, that the understanding of quality according to Plato is covered, as a special case, by Aristotle's understanding of quality. Value, which is the fundamental category of axiology, is therefore tone of the features that characterise objects in relations with human beings. Such a viewpoint resulted in the fact that in this publication the principle of creating the terminological concept of qualitology based on Aristotle's approach was adopted (see Item 3.1).

The problems of axiology are difficult, mainly due to the subjectivism of the systems of values and the application thereof. The creation and operating application of axiological methodology include, inter alia, the area of the theory of quality evaluation under qualitology (see Items 4.4 and 5.9) and theory of economic and psychological value. In the economic theory of value, economic categories are used to describe and analyse the relation between human beings and products in the process of responding to needs (see Item 5.12). The connection of economic categories with quality of objects gives grounds for the **economic evaluation of quality**. In line with the psychological theory of value, measures of value include the intensity of experience or the power of a person's desire, expressed in their preferences and

[2] This position corresponds to the view of I. Kant mentioned earlier, regarding the subjectivity of quality.

behaviour. The connection of selected psychological categories with quality of objects gives grounds for the **psychological evaluation of quality**.

The above deliberations demonstrate that the theoretical sources of qualitology are rooted mainly in the to-date accomplishments of philosophy and in quality management theory and engineering. The assumption that the framework of qualitology is built based on these very foundations should not be a controversy. In particular, it consists in the creation of qualitative terms taking into the ontological, epistemological and axiological approaches. The "philosophy of quality" conceived in this manner should be next combined with the approaches presented by the quality management theory and engineering. Concurrently, a hypothesis is made that the sources of qualitology allow e.g., to develop the principles underlying the qualitative approach, which will constitute the new **qualitological paradigm** in the recognition and creation of reality by human beings (Chapter 5).

Chapter II

SUBJECT OF QUALITOLOGY AS THE SCIENCE OF QUALITY

2.1. Specification of the scope of reality as the object of qualitological research

The subject of a scientific discipline is its most important and, concurrently, most general characteristics. The constitutive elements of the object of any scientific discipline, including qualitology, comprise [20, 32, 34]:

- **scope of reality** studied by the specific scientific discipline,
- **research consideration** which covers the specific scope of reality,
- **research objectives**, both theoretical and practical,
- **instruments**, **methods,** and **methodology** of research.

The term "reality" means **everything that is**, regardless of the form, circumstances, time, and manners of existing. This means that reality is made up not only of material, objective, independent and genuine components, but also of immaterial (abstract, virtual, spiritual), subjective, dependent, and untrue. Therefore, for instance, reality comprises also such components as language, information, phenomenon, opinion, evaluation, emotion, legend, myth, fantasy, lie, feeling. As a result of a cognitive process, human being concludes that the fact that a certain component of reality exists in a given time. In this book, the components of reality isolated in the processes of decomposition and structuring will be referred to herein as **objects**.

The scope of reality for the purpose of qualitology will be based on premises indicated in Chapter 1. Philosophical premises suggest that **the category of quality can exercise a general, material, and universal cognitive (epistemological) function in reference to any object**. This function is covered by answers to the general questions: What is an object, what was it or what will it be like? or How does an object exist, how did it or how will it exist? In the cognitive function of quality, as a special case, the axiological function is also included, reflected in the answer to the following question: What is, was or will be the object's value? In the question posed in this manner, the category of **quality** occurs as a special **feature** of an object's quality, which pertains to the evaluating relation of man with an object. In the concept of qualitology created by the author, the second specific and equally important **feature** taken into account when determining the quality of objects is the category of **quantity** (3.2 and 4.1).

When considering the relationship between the most general, ontological categories of matter and things, and the epistemological categories of quality and feature, a certain symmetry may be noticed and one may conclude that matter and quality are collective categories (comprehensive, synthetic), whereas things and features are elementary categories (partial, analytical). Features and quality describe matter and things, as well as all other types of objects, and they are not autonomous (self-reliant, independent). They occur exclusively in relation with the existence of the subject in the relationship to the object of cognition. They make it possible for the subject of cognition to create informative images of reality e.g., in the form of scientific knowledge systems and **cognitive** and **postulative** models of objects.

In qualitology, the assumption that the categories of **quality and feature** are the basic epistemological categories has been regarded as grounded (see Chapter 3). Gradual disintegration, specification and exemplification of these categories occur in the discovery process of detailed knowledge regarding existing objects which is, inter alia, the task of individual scientific disciplines and fields of practice. This process results in the designata of general terms of quality and feature, referred to specific objects.

Taking the above assumptions and arguments into account, it may be concluded that the **categories of feature and quality may be related (affiliated**, **assigned or allocated) to any object that is studied or created**. Therefore, it may be concluded that the scope and object of qualitological studies cover **the whole reality**, including all its components[1]. The general structure of reality that is being studied by qualitology, taking in

[1] It may be noticed that in practice and in literature on quality management, the scope of qualitological research has been practically limited to the reality comprising artificial objects.

particular the position of a human being as the subject of creation and cognition[2] is presented in Figure 2.1.

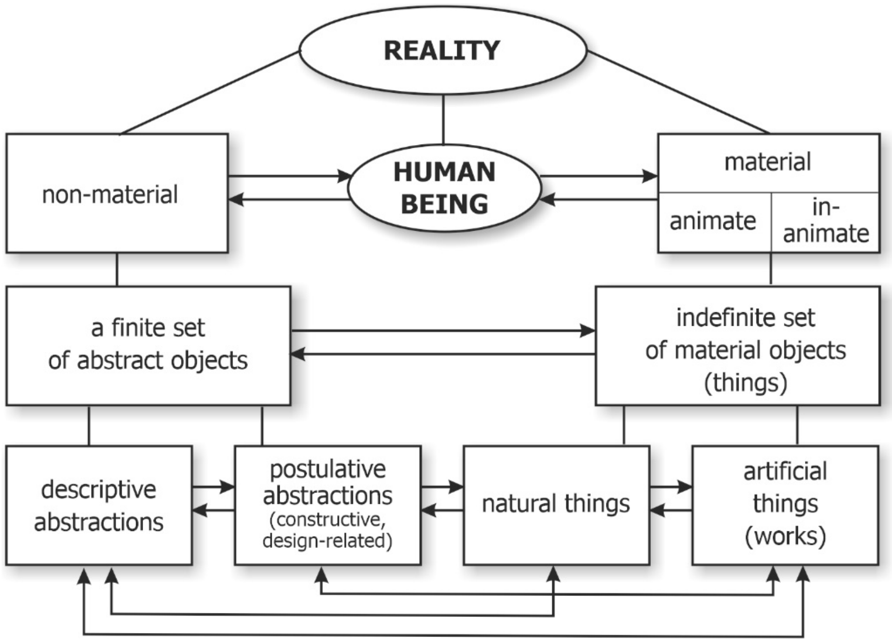

Fig. 2.1. Substantive scope of qualitology

In the first degree of expansion, three scopes of reality have been distinguished [17, p. 22]:

- **human being**, i.e. a natural phenomenon, occurring as subjects that are isolated in different manners: people, social groups, organisations, and the entire human community,
- **material reality**[3] animate and inanimate, which comprises an indefinite set of material objects (things),
- **non-material reality**, which comprises a finite set of abstract objects (abstractions, mental creations).

In the anthropocentric approach, the central place in the structure of reality is occupied by human being and relationships with other components of reality. These relationships manifest the role of a human being as the **subject of cognition and the creator of changes to reality** which

[2] Human being, as a component of a material, animate reality, is also the subject of cognition.

[3] Material reality is understood as a universal and independent existence assuming many physical forms, such as mass, energy, antimatter, dark matter, radiation.

corresponds to the human being's **cognitive**, **creative,** and **causative** function. The special position results from human being's phenomenal quality which comprises, inter alia, such features as perception, memory, thought, imagination, creativity, anticipation, and intelligence. In the process-based approach, the quality of a human being is determined by the **quality of life**. Things are an ontological category, they build the structure of the universe of existence, and exist independently of human beings, intrinsically and objectively. The specificity of the quality of things, when compared with the quality of abstractions, results from their material nature and is determined by the attributes of matter. It is worth indicating a material qualitative difference between the objects of material animate and inanimate reality. Animate reality comprises any and all plants and animals that demonstrates the **features of life** such as metabolism, development, evolution, and reproduction.

Abstractions are an epistemological category, they are not independent existences, they exist in relation with human beings and other things. Human being is their sole creator and operator. Typical examples of systematised abstractions include natural, artificial, national, community, specialist, machine, technical and other languages created and used by man. Languages are tools for the creation, accumulation, storage and forwarding of information and knowledge in the processes of human communication. When creating and organising an abstract reality, human beings creates a virtual world at their service. Features and quality, adopted for the purpose of qualitology as **basic abstractions**, serve the creation of other abstractions in the processes of specifying their semantic meaning.

In the second degree of expansion of the structure of reality the following was distinguished:

- **material natural reality** in the form of an indefinite set of natural things that were created in natural processes (physical, chemical, biological, physiological etc.),
- **material artificial reality** in the form of a finite set of artificial things that were created as a result of creative and manufacturing activities of man,
- **non-material descriptive reality** in the form of a finite set of cognitive abstractions that serve the cognition of reality and human communication in this respect,
- **non-material creative reality** in the form of a finite set of postulative abstractions that serve the intended change of reality and human communication in this respect.

We describe artificial objects as such that were created as a result of mental and/or physical activity of man. Based on this criterion, artificial objects class includes all objects that were created in the process of intended and unintended, as well as conscious and unconscious activity of man. In this class, one may distinguish a sub-class of objects which were created as a result of **intended** and **conscious** activity of man. Such class of activity is called operation. Artificial objects that were created in the process of unintended or unconscious activity of man comprised a complementary sub-class.

Based on the to-date deliberations, abstract reality is made up solely of artificial objects that are the creation of human thought. In abstract reality, cognitive abstractions were distinguished, which are the consequences of the cognitive operation of man, consisting in the **discovery of the truth of reality** and postulative abstractions that are effects of human knowledge, creative imagination and fantasy, e.g., innovations, concepts, constructs, designs, plans, programmes, mythologies, works of literatures, works of art, science fiction. The main reasons for creating postulative abstractions is the drive to the **intended change of reality**. Concepts of abstractions are explained through the determination of their quality.

If the actions of man, oriented by postulative abstractions, cause the transformation of a specific section of material reality, then we deal with the manufacturing of artificial things (works, goods, commodities). Many manufacturing processes result from natural things (e.g., minerals, raw materials, natural plants, not farmed animals). The phenomenon of a human being consists in the intended creation of an artificial abstract and material reality, in close relationship with natural material reality, with the intention of satisfying their needs as much as possible.

Special components of reality include the relations that make up its structure, they are presented in general in Figure 2.1 as arrows. Overall, the full set of relationships includes all relationships that occur between each object and all other objects of reality. What should be assumed as obvious is the statement that analysis and gradual decomposition (division, expansion, classification) of objects comprising reality lead, in line with the principles of combinatorics, to the dynamic increase in the complexity of the **network of relationships** between objects.

The exceptional importance of the network of relationships as a component of the scope of reality taken into consideration by qualitology results from the thesis regarding the necessity to study the network of relationships between a specific object and other objects in the process of determining the quality of this object. According to this thesis, **quality of each object is determined on the grounds of the relationships with other**

objects and without studying them it is impossible to determine the quality of object. This also means that quality of an object is a function of these relationships.

An example relationship matrix for the first degree of expansion of the reality's structure is as follows:

$$\mathbf{R} = \begin{array}{c|ccc} & \mathbf{L} & \mathbf{M} & \mathbf{A} \\ \mathbf{L} & \mathbf{R}_{LL} & \mathbf{R}_{LM} & \mathbf{R}_{LA} \\ \mathbf{M} & \mathbf{R}_{ML} & \mathbf{R}_{MM} & \mathbf{R}_{MA} \\ \mathbf{A} & \mathbf{R}_{AL} & \mathbf{R}_{AM} & \mathbf{R}_{AA} \end{array} \qquad (2.1)$$

where:

R – relationship matrix of **L**, **M**, **A** class objects,
L – set of subjects,
M – set of material objects,
A – set of abstract objects.

The matrix comprises three rows and three columns of three sets of relationships each, from which we gain knowledge of the quality of subjects, things and abstractions respectively, that results from the studies of mutual relationships of each of these sets with subjects, things and abstractions. The diagonal of the matrix includes three sets of relations: subjects to subjects $\mathbf{R}_{LL}$, studied by, inter alia, social sciences, things to things $\mathbf{R}_{MM}$, analysed by, inter alia, physical sciences, and abstractions to abstractions $\mathbf{R}_{AA}$, studies by, inter alia, linguistic sciences.

All objects that make up reality are bound with the category of time. Regardless of their form and type, **objects can only exist in time**, which is a measurable feature, and which may be treated as a fully universal feature i.e., assigned to all objects. In general, time is an indefinite quantity and in the time axis a specific range thereof may be isolated. A typical time range is the period of the object's existence. During their existence, objects usually undergo qualitative changes. The period of existence of abstract objects is the time they exist in the human consciousness and communication. According to the materialistic direction in philosophy, indefinite existence of matter is assumed, which means that despite qualitative transformations over time, each thing always retains the features of matter. Therefore, in order to isolate a specific thing in the set of other things, features from beyond the universal features of matter are used.

To conclude the deliberations on the substantive scope of qualitology, it is worth stressing that covering the entire reality results from the function of the category of quality and feature and, concurrently, means that a very general and comprehensive research perspective in the general theory of quality. Thus, it should not be expected that the general theory of quality would bring a direct and detailed knowledge of reality. It should, on the other hand, create methodological foundations for a universal, quality-based approach to the study and shaping of reality, which will then be applied in specific theories of quality and quality engineering, as well as in many other scientific disciplines.

2.2. Description of the research consideration

The research consideration of qualitology basically results from the adopted definitions of quality and other fundamental quality-related terms (Chapters 3 and 4). These definitions and the to-date deliberations on quality lead to a conclusion that it is grounded to regard quality categories as fundamental and the most general cognitive categories. The adopted definition of quality does not assume any limits as to the power of the set and type of features of each object, however it allows the possibility of introducing such limits for practical, efficiency and other reasons that occur in real cognitive, creative and manufacturing processes.

The above means that the qualitology's research consideration is a reflection of the **quality-related examination of reality** and basically covers **all possible characteristics** of each object and takes into consideration the pursuit of possibly the fullest and most comprehensible study of their nature. Therefore, to expand the research consideration of qualitology leads, for instance, to taking into account the research aspects of all scientific disciplines that study specific objects and provide knowledge that is relatively more specific and detailed than the general approach. These disciplines deal with specific fragmentary qualities of objects, whereas qualitology focuses on the general comprehensive quality and its structure. Methodological expansion of the research consideration of qualitology include, inter alia, basic quality-related operations (Chapter 4) and the principles of quality-related approach in the study and shaping of objects (Chapter 5).

The assumed definitions of qualitative categories and material scope of qualitology lead to the expansion of the research consideration and research perspectives in reference to a situation wherein only a value-based interpretation of quality is adopted[4]. This expansion is reflected in three research perspectives:

[4] The interpretation narrowed down in this manner occurs at the moment usually as a result of a universal application of a definition of quality assumed in standard ISO 9000:2015 ("Quality – degree to which a set of inherent characteristics of an object fulfils requirements").

- **descriptive**, trying, using quality modelling methods, to study the nature of objects by answering the question: what are, were or what will they be?,
- **comparative**, aiming at, using comparative quality testing methods, classification, and organisation of objects by answering the question: how are, were or will they be similar or different?,
- **axiological**, aiming at, using the quality evaluation methods, value-based hierarchy of qualitative categories and objects by answering the question: what are, were or will they be worth?

A methodological principle has been regarded as grounded, according to which each of the mentioned research perspectives should take into account the fourth perspective – **time-based**, which allows the reference of quality of objects to past, presence and future.

Under the descriptive research perspective of quality a theory should be developed, covering the methodology of building quality models (mappings, images) of objects. These models would create and gradually expand the knowledge of objects and would make it possible to study them, identify and communicate, consisting in the collection, transmission, reception and use of information on object quality. To perform these tasks, especially the **methodology of determining object quality** is needed (Item 4.1). Quality-based modelling is used both in the study and creation of objects. The descriptive perspective provides basis and is a condition for the application of the remaining research perspectives.

In the comparative perspective, the research process covers a specific set of objects, and similarities and differences in their quality are determined using comparative analysis. This is an extremely important cognitive operation, allowing, inter alia, the structuring of reality and classification of objects. The theory of research and comparative analyses should contain the **methodology and methods of comparison** (Item 4.3), **systemisation** (Item 4.2) and **classification** (Item 6.3) of object quality. The knowledge of quality-related similarities and differences between objects is also required for quality management (Item 4.6) and solving linguistic problems (Item 6.2).

The axiological research perspective takes into consideration the needs and systems of human values in the determination, evaluation, optimisation, and comparison of object quality. This also means that any and all actions regarding quality, by definition characterised by purpose, take into consideration the values, needs, goals and requirements of man. A condition for rationality of the application of the axiological perspective is the development of **methodology and methods of evaluation** (Item 4.4) and **optimisation** (Item 4.5) of object quality. The following principles of a quality-based approach result directly from the axiological perspective: anthropocentrism

(Item 5.3), evaluation (Item 5.9), optimisation (Item 5.10), standardisation (Item 5.11) and economics (Item 5.12).

The above-mentioned deliberations show that the research consideration of qualitology is one of the most general considerations and comprises a specific "methodological superstructure" for research considerations of all the scientific disciplines that develop, specify and expand the fragmentary qualities of specific classes of objects.

2.3. Main goals of qualitology

The goals of qualitology as a science of quality, similarly as the goals of other scientific disciplines, result from the needs in the activities of human beings and the necessity to satisfy them. The basic and the most general division of these activities takes into account the need for cognition and purpose-driven change of reality. The scientific and theoretical activities derive from the need of cognition, whereas the engineering and practical activities stem from the need of change. Taking the above into account, the main goals of qualitology may be divided into two basic groups.

1. **Cognitive goals (theoretical, scientific)** – reflecting the man's drive towards the acquisition and accumulation of the fullest knowledge of reality through the creation of adequate qualitative models of objects. The achievement of these goals is subject to the **criterion of truth**, the use of which is a prerequisite for the effectiveness of employing the scientific achievements in practical operations.
2. **Practical goals (engineering, constructive)** – reflecting man's aim to make intended changes to reality through the creation of qualitative, postulative models of objects (concepts, designs, plans, programmes etc.), then materialised in the manufacturing operations. In pursuit of these goals the following criteria apply: **rationality**, **optimum** and **effectiveness**. Rationality means that engineering activities are based on the principles of scientific and logical reasoning. Optimum is the search for, and application of the best solutions and effectiveness means a high degree of meeting the goals behind the actions. Solutions serving directly the achievement of practical goals should be provided by quality engineering.

The goals of the first and second group may be achieved as a result of a harmonious development of theory and quality engineering within the framework of qualitology. The thing is, primarily, the development of the theory of quality, in particular the inventory, analysis and organisation of existing knowledge of the topic, which is characterised by considerable diversity, dispersion and incoherence, and the creation of a general theory of quality, to provide methodological grounds for specific theories of quality and quality engineering. The general theory of quality should include, inter alia, the solution to the problem of approach and qualitative modelling. On the other hand, solutions which are directly useful for the purposes of quality engineering should be delivered by specific theories of quality (Item 2.5).

The goals of the second group are achieved mainly as a result of the development of quality engineering and practice of shaping quality. The thing is, primarily, to assure systemisation and improvement of existing quality engineering methods applied, inter alia, to the determination, measurement, design, manufacturing and use of the quality of artificial objects. This whole problem, in its organisational and systemic aspects, is now quite well included in the framework of quality management engineering. The quality engineering should deliver organisational, technical, economic, social, and other methods for continuous improvement of efficiency and effectiveness in the quality management practice.

One of the main goals of the further development of qualitology is the elimination of drawbacks and reaching harmony between the theoretical and engineering trends. Major tasks in this respect include:

- expansion of the material scope of qualitological research onto the entire reality (all objects, not only artificial ones),
- assuming a multi-faceted, comprehensive understanding and testing of objects quality without ungrounded limits,
- organisation of terminology through the development of a coherent system of basic qualitological terms,
- development of general and specific theories of quality as a basis for the development of quality engineering and then an effective quality assurance practice.

In a synthetic approach, **the general goal of qualitology is to build scientific basis for qualitative cognition and shaping of reality by man.**

2.4. Methodological instruments

Along with the onset and development of any scientific discipline, also the instruments of methodology and methods that prove its maturity is being developed. Qualitology is at an early stage of development, despite the fact that some of its elements (e.g., quality in philosophy, commodity science, quality management) are significantly advanced. Based on the review of literature, one can conclude that methods and instruments of quality engineering that most scientific studies refer to, are quite well developed, e.g., [4, 9, 14, 16, 18, 21, 22, 25, 27, 28, 31, 36, 50, 54, 65], whereas quality theory is rather insufficiently developed, e.g., [6, 7, 17, 29, 38][5]. Many premises indicate that there are grounds to suppose that the reason for such a situation is the domination of the needs to solve quality-related problems in economy, especially in manufacturing and trading operations.

A fundamental issue in the creation of methods and instruments of qualitology is to determine the primary and basic terms and to develop an adequate language for the discipline (Chapter 3). Each language is a system of signs equipped with specific semantic values which have two basic functions:

- model functions, as it allows the creation of informative models of objects,
- communicative function, as it allows the transfer of information and communication of subjects.

Effective performance of these functions depends on an accurate and precise semantic convention, assuring, inter alia, the explicitness of terms by the sender and receiver. The problem of explicitness and, more generally, qualitative similarity of terms, may also have material practical consequences resulting from an ineffective communication while handling multi-subject activities. To solve this problem, it is recommended to apply the qualitological approach (Item 6.2).

Methods and instruments of quality management are the most developed, e.g., [4, 12, 14, 16, 17, 18, 21, 25, 31, 36, 38, 44, 45, 49, 50, 51, 54, 65, 69]. For instance, in work [11, p. 208-211] quality management instruments were divided into three groups:

- quality management principles (e.g., Deming principles, continuous development principle, zero defects, teamwork, *poka-yoke*),
- quality management methods (e.g., QFD, FMEA, SKO, SPC, DOE, value analysis, Shainin, Taguchi),
- quality management tools (e.g., flowcharts, Ishikawa diagram, Pareto diagram, histogram, check sheet, correlations diagram, check card, relationships diagram, affinity diagram, systematics diagram, matrix diagram, arrow diagram, matrix data analysis).

The size and complexity of methodological instruments make it impossible to thoroughly characterise them at this point. They are well described in qualitological literature, pertaining in particular to quality management. These are mostly instruments of high practical usability, adequate for quality engineering. In further chapters of this book instruments of methodology and methods will be developed, adequate for the approach that is relevant to the general theory of quality.

[5] The reader should pay special attention to works [7] and [29], due to their significance for the theory of quality.

2.5. Qualitology division concept

The complexity of the subject of qualitology signalled in the previous subchapters indicates that this is not a monolithic science. This was already noticed earlier, and the literature on the topic contains original concepts of the division of qualitology according to scope and subject matter [7, 17, 27, 29]. However, at the current stage of the development of qualitology, there is no single, universally recognised division of the science, that has been only suggested for to date. Therefore, a universal, multi-criteria structuring of the science of quality is possible, as well as the creation of many proposals as to how to divide it, which is concurrently conducive to the development of many premises for further development of this discipline of knowledge. However, when proposing the division of qualitology, one should focus on the criteria of the cohesion of science and adequacy with regard to the existing and expected and desired achievement of this scientific discipline.

Taking the above criteria into consideration, Figure 2.2 presents an original concept of the division of qualitology.

The first degree of division assumes a bi-state criterion of the qualitology's goal: cognitive goal, adequate to the theory and true cognition of reality, as well as a practical goal, adequate to the engineering and efficiency of actions. The domination of the cognitive goal corresponds to the **theory of quality** (basic qualitology [29, p. 26]), and the domination of the efficiency-related goal corresponds to **quality engineering** (applied qualitology [29, p. 26]). Both parts of qualitology are strongly integrated and it is not worth searching for or outline a clear boundary between them.

The second degree of the division generates more components which cannot, at this point, be sufficiently expanded and described. The general theory of quality covers a system of axioms, definitions, theorems, rights, dependencies, and universal models of methodological nature, that constitute the top of the "pyramid of knowledge" of quality and referring to the general subject of qualitology. Special theories of quality refer to specific components of the subject. The postulate of creating special theories of quality, adequate to the individual branch of quality engineering is regarded as rational.

In quality engineering a few sample branches have been isolated, which already demonstrate considerable achievements in terms of literature and practice. Commodity science is a recognised branch of knowledge and practice when it comes to the determination and evaluation of quality of consumer goods. Qualimetry deals with constructing the tools for numerical, accurate and objective measurement of qualitative categories [2, 3]. The quality management instruments comprise the principles, methods, tools, models for shaping quality in organisations.

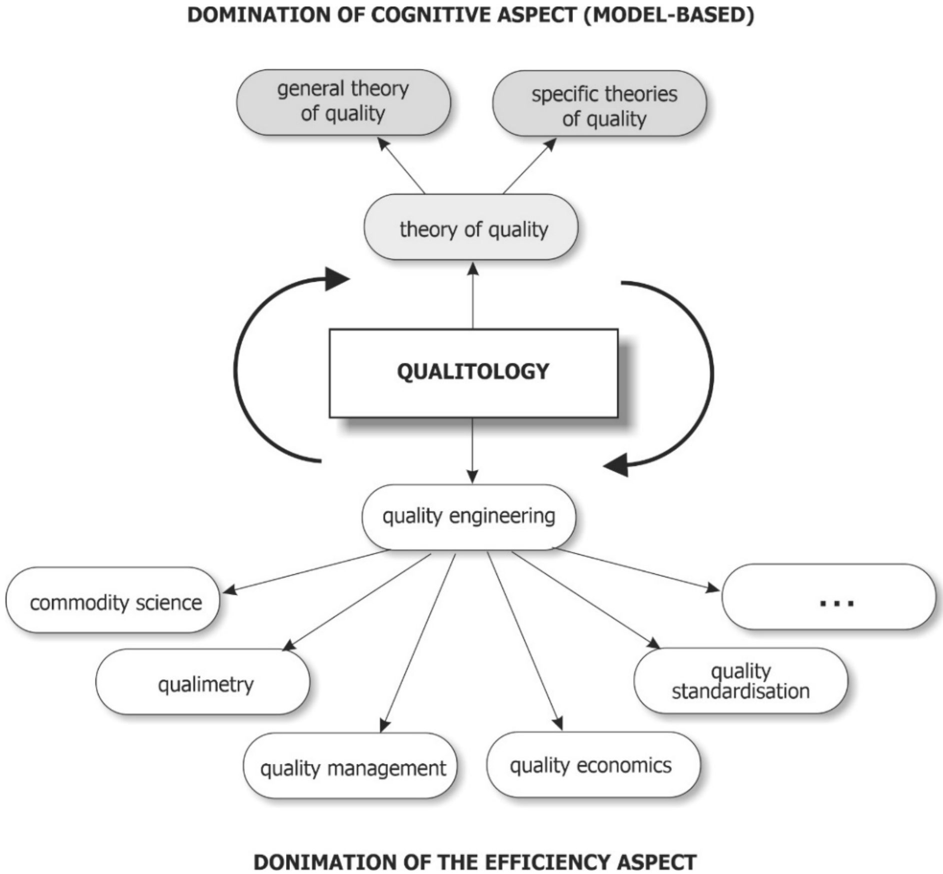

Fig. 2.2. Qualitology division concept

The methods of quality economics are supposed to facilitate the analysis of quality-related events and undertakings on the economic level. This concern, inter alia, the account of economic effectiveness of quality-related decisions. The methods of standardisation of quality are aimed to assure, in practice, a rational limitation of an infinite number and diversity of the project solutions to quality-related problems.

The qualitology division concept presented in Figure 2.2 is not the only one possible. The division may be based upon various criteria:

1. **Classification of organisations created by man and their activities**. The problem pertains both to the characteristics and classification of

all organisations, as well as the characteristics and classification of operations within organisations belonging to specific classes. For instance, organisations may be divided into economic, social, academic, political, professional, military, cultural, sports etc. On the other hand, operations within an organisation may be divided according to function, e.g., management (planning, organisation, leading and control), and performance (design, manufacturing, communication, investment etc.). Based on the classification proposed above, the following qualitology aspects can be isolated: economic, industrial, social, management and manufacturing.

2. **Stages of the life cycle of works**. The general structure of the cycle is made up of five stages. The stage of manufacturing preparation comprises the research and design stage and the organisational and material preparation stage. The general object of qualitological research at this stage is the quality of manufacturing preparation and the impact thereof on the designed objects of the entire cycle and the quality of organisational and material preparation. The manufacturing stage comprises a set of actions undertaken by organisations in order to obtain, in an adequate time, the planned number of homogeneous, in terms of quality, copies of the work, that are the actual counterparts of the comprehensive design quality. In this stage, the problems of qualitology pertain to the manufacturing quality. In the distribution stage, the flow of the copies of the work from the manufacturer to the user is assured. Therefore, the general object of qualitological research is the quality of distribution. The operating stage covers all actions of the user aimed at gaining the maximum, in quantitative and qualitative terms, useful effect of the copy of the work. In this stage, the general object of qualitological research is the quality of operation, including the quality of useful effect. The subject of qualitological research in the last stage of the cycle is the quality of liquidation of the copies of works, and therefore the quality of waste.
3. **Elementary qualitative operations**. The division of qualitology according to this criterion takes into consideration the specificity of research problems that result from exercising fundamental operations on quality-related categories (Chapt. 4).
4. **Principles of quality-based approach**. The division of qualitology according to this criterion takes into consideration the specificity of research problems that result from the development and application of individual principles of the quality-based approach (Chapt. 5).
5. **Supporting academic disciplines** (Item 1.2). The division of qualitology according to this criterion takes into account and uses the achievements of the supporting academic disciplines. Therefore, for instance, the

following aspects of qualitology may be isolated: mathematical, technical, psychological, economic, IT, legal.

6. **Material scope of qualitology** (Item 2.1). The division of qualitology according to this criterion is concurrent with the structure of reality presented in Item 2.1 and in Fig. 2.1. Individual classes of objects may provide grounds to isolate branches of qualitology, such as the qualitology of things, qualitology of abstractions or qualitology of works.

The presented multi-criterion concept of qualitology division is not a closed one, therefore it may be used as an object of further analysis and improvement. Also, the possibility of applying other criteria for structuring qualitology and for a more detailed division is not ruled out.

Chapter III

ELEMENTS OF TERMINOLOGICAL CONVENTION

3.1. Basic terms and definitions

In literature on quality, there are many diverse terminological proposals regarding basic qualitology terms. Without an exhaustive analysis thereof, it is worth stating that most definitions relate to the Plato's axiological approach to quality or a descriptive approach adopted by Aristotle. Thus, in the general socio-economic practice, quality is most often defined as specifically determined value of objects, mainly products. Therefore, the definitions of quality may be divided into three groups:

- definitions in line with which quality is an ensemble (scheme, set) of features (properties, attributes, traits, and characteristics) describing an object and proving the object to be the one and not another,
- definitions, in line with which quality is the degree (level) at which a given object meets the requirements resulting from specific needs of subjects,
- definitions in line with which quality is an ensemble of features of a given object that meet an ensemble of requirements resulting from specific needs of subjects.

The first group of definitions assures scalable, in terms of complexity of the ensemble of features, **cognition of the essence** (characteristics, identities, forms) of the object. Thus, defined quality is a multifaceted characteristic thereof, allowing e.g., identification operations and multi-aspect comparative analyses within a set of objects. In definitions belonging to the second group, object quality is regarded as a **specific value** determined by the degree to which requirements are met. In this case quality is a function of variables, diverse and often subjective requirements of specific subjects and the object's capacity to meet them. Thus, defined quality serves e.g., value-based hierarchisation of objects and making decisions in line with the principle of maximising the degree of meeting requirements. In the third group of definitions, quality is limited to the subset of these features which demonstrate a positive relation with requirements regarding a given object. Quality understood in this manner is evaluative and pertains to desired, in terms of requirements, features of an object. This group of definitions, however, does not take into account the undesirable (making a negative impact on meeting requirements) as well as neutral features and does not assure value-based hierarchisation of objects.

The concept of terminological convention attempted in this publication is based on the characteristics of the object of qualitology (Chapt. 2), according to which the basic ontological categories comprise things and matter, and epistemological categories – cover features and quality[1]. The categories of feature and quality are basic abstractions and their designata serve the purpose of giving semantic meaning to other abstractions that characterise objects. As a result of cognitive operations, features and quality of objects are identified (things and abstractions), as a result of which one gains information to develop knowledge of reality. This knowledge may be non-evaluated (**non-evaluated quality** of objects) or evaluated in nature (**evaluated quality**). This knowledge may also reflect **value** i.e., constitute a set of features of value[2].

Such an approach to the fundamental issues of qualitology differs considerably from, commonly occurring in practice, approaches typical for colloquial language and from the theoretical studies of approaches such as commodity science, technical, economic, functional, legal, marketing, ergonomic, psychological, sozological etc. These are less general approaches, therefore more specific and practical. On the other hand, for the purpose of the developed concept, the most general approach to quality has been adopted, corresponding to the general theory of quality, from which more specific approaches will result e.g., the ones mentioned above. This corresponds with

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[1] An interesting, valuable, and original concept of a coherent scheme of basis qualitological definitions was developed based on the mapping theory by Tadeusz Borys [6, 7]. He defined quality as an m-dimensional function taking into consideration a set of feedbacks between relatively homogeneous objects with the images thereof. The advantages of this concepts are highlighted by an accurate formal record.

[2] For the set of the features of value, the adequate name is "evaluated quality", assuming that this name is not identified with a positive evaluation of quality (in this case ambiguous interpretation is possible).

the proposal to separate a general theory and specific theories of quality and quality engineering and the branches thereof (see Fig. 2.2).

Feature is assumed as the starting qualitological category, which is regarded as the name of the elementary primary notion. In order to present the term in more detail and facilitate unambiguous understanding, it may be added that it is an isolated element of what is stated with regard to an object as a result of the thought process, while formulating an answer to the following question: **what is the object like**? (see [54, p. 233]). Therefore, a feature is the carrier of a certain **portion of information** regarding the object (see Item 3.3). In the processes of development, making more specific and detailed, as well as creation of the designata of the general term of "feature", analogous changes occur in the area of information and knowledge of objects. One may also suggest that similarity occurs as regards the understanding of this term in qualitology and the term "**variable**" in mathematics. Based on the to-date deliberations, the notion of feature is the most **universal**, **fundamental,** and **elementary abstraction** carrier of a certain portion of information which is a material in constructing other, more complex in terms of information, and specific abstractions. Firstly, the notion of **quality** will be this complex and most general abstraction.

Treating feature as a primary notion allows, among others, to determine quality using only primary terms in *definiens*.

Description 3.1. **Quality depicts a set of features**[3],

$$\mathbf{J} = \{c_1, c_2, c_3, ...\} \text{ or } \mathbf{J} = \{c_1, c_2, ..., c_n\}, \text{ or } \mathbf{J} = \varnothing.$$

In line with this concise and, concurrently, unambiguous, and accurate definition, quality is used as a term equate with a multi-dimensional space of features. The use of the term "set" has significant consequences for the developed qualitological concepts, as it allows the use of the achievements of the set theory, including the algebra of sets [56].

A set, as well as belonging to one, are the fundamental and primary terms in mathematics, used in the sense of multitude (group, class, space) of objects named by elements which belong to the set [56, p. 81, 52, p. 31]. Features (c_1, c_2, ..., c_n) are the elements of a specific set (**J**), called quality.

[3] In the proposed description, the phrase "depict" is used as this is a terminological convention, to which the criterion of truth does not apply [43, p. 14-15]. The descriptions presented herein belong to a class of semantic, stipulative and classical definitions (see: [70, p. 48-52]).

The triple formal notation of quality in definition 3.1 means that it may take on the form of an infinite, finite or empty set[4].

An infinite set of features occurs in the case of material objects; it results from the assumptions that their nature is impossible to be absolutely known to the fullest extent. This assumption also gives rise to a relative complexity of the quality of these objects and the possibility of systematic increase of the cardinality of the set of known features, which means an increase in the relative complexity of their quality as knowledge develops.

A finite set of features occurs in the case of abstract objects and pragmatic simplification in the use of the quality of material objects in practice. The finiteness of the set of features of abstractions results from semantic decisions made in the processes of the development thereof. Multi-subjectivity in the creation of abstractions causes the parallel occurrences of many qualities of an abstraction, which means that the same term carries different meanings (homonymic terms). One of the methods to prevent this phenomenon, which makes communication difficult, is the drive towards common acceptance of a single quality assigned to one term, through the adoption of one semantic convention[5].

The occurrence of an empty set of features pertains to a situation wherein we express a potential quality, or we do not know anything about a specific object, therefore its features are unknown. This situation may constitute grounds for making a decision on the creation of features or instituting research to discover the features and quality of a hypothetical object.

One of the basic properties of quality is the **size** (cardinality) of a set of features expressed as a natural number [71, p. 73-75]. If the features of quality taken into consideration are put in order according to the adopted ordering relation, then another feature of a set – will emerge i.e., **arrangement**, and quality will take on a form of an ordered set.

Beside the use of the term "quality" as any other abstraction, the legitimacy of the application of the imperative of using quality in relation to an object (p), to which it belongs: $\mathbf{J}^{p} \leftrightarrow p$ should be stated. Therefore, the basic method to create quality as a set of features is to adopt the property of "features belonging to an object $-F(c)$" as a basis for assigning individual features to the quality of a given object. Taken individually, **only, and**

[4] The formal notation of quality in further fragments of the book will be usually limited to a finite set, as when handling quality in practical terms, this form is most frequently encountered.

[5] In line with this interpretation, abstractions of language or a very similar or identical quality (terms close in meaning or identical) are synonyms.

exclusively, those features to which the property F(c) **belongs, are assigned to the quality of object**: $\{c \in \mathbf{J}^p : F(c)\}$.

The interpretation of quality on the grounds of fuzzy sets, using the **membership function** (μ_J) of set **J** of the value within the range of $\langle 0, 1 \rangle$ is very illuminating qualitological problem, not signalled to date in literature. The function serves the purpose of defining the degree of membership of individual features to set **J**, which, in this case, may be called **fuzzy quality** $\mathbf{J}_r$. Fuzzy quality will be then a set of ordered pairs (see [67, 68]):

$$\mathbf{J}_r = \{(c, \mu_J(c)) \mid c \in \mathbf{J}\}, \text{ and } \mu_J: \mathbf{J} \rightarrow [0, 1]. \quad (3.1)$$

The membership of features in objects is determined in cognitive research activities (**discovered quality**) or in creative design activities (**postulated quality**). Discovered quality pertains to existing objects and postulated quality – to designed objects. Such an approach makes it possible for quality to play the function of a multi-aspect definition of any object.

Description 3.2. **Quality of an object depicts the set of features belonging to it**,

$$\mathbf{J}^p = \{c^p_1, c^p_2, \ldots, c^p_n\}.$$

In line with definition 3.2, the perception of the quality of any object consists in the discovery or postulating and semiotic phrasing of a set of features of this object in the following processes: diagnostic, prognostic or design, in which this object constitutes an object of diagnosis, prognosis or design.

Two operations, that are cognitively interesting, are related to the quality of objects. First is the objective determination of the quality of a given object: $p \rightarrow \mathbf{J}^p$. This operation may be called the **qualitative modelling of objects**. The second operation consists in the identification of an object based on given quality: $\mathbf{J} \rightarrow p$. This operation allows the creation of sets of objects with specific qualities, which provides, among others, grounds for **typology and classification** of objects (Item 6.3).

In the process of assigning features to an object, a logical formula of the following type is employed: $A \vee \sim A$ (fact *A* occurs or not) and the following problem is resolved: whether specific features are ($c \in \mathbf{J}^p$) or are not ($c \notin \mathbf{J}^p$) members of the object. In the case of the application of fuzzy logic, when applying the membership function μ_J, the degree of membership of individual features in the quality of a given object must be determined. Thus, the fuzzy quality of an object emerges from membership features that are above zero. A set of features for which $\mu_J(c) > 0$, is called a **carrier** of fuzzy quality, and a set of features for which $\mu_J(c) = 1$, is called **core** of fuzzy quality.

If, in the research process regarding an object, new phenomena and facts are discovered, then in other to describe them, new features need to be created, thus expanding the database of known features. New proper names need to be created for new features. Using quality, humans map the material and abstract objects, create, inter alia, other abstractions thus allowing mental operations, communication, and rational use of objects.

In order to map the assignment of features and quality to objects, one may define two **functions of quality** in general notation (see: [61, p. 79-80]). The function F_C represent analytical approach and assigns features from set **C** to objects from set **P**. The function F_J represents a synthetic approach and assigns qualities from set $\mathbf{R_J}$ to objects from set **P**.

$$F_C : \mathbf{P} \rightarrow \mathbf{C} \text{ and } F_J : \mathbf{P} \rightarrow \mathbf{R_J}. \qquad (3.2)$$

where:
F_C – function of quality for features,
F_J – function of quality for quality,
C – set of features,
$\mathbf{R_J}$ – set of qualities ($\mathbf{R_J} = \{\mathbf{J}_1, \mathbf{J}_2, ..., \mathbf{J}_n\}$, set of sets of features – family of sets[6]),
P – a set of objects.

While defining the quality of objects based on features, the **first and general level of cognition** is taken into consideration. Such a level of cognition results from the fact that the names of features are formulated descriptively in a given language and determine their conceptual meaning. The analysis of the occurrence and application of features leads to a conclusion that they are in fact identified on objects only in the form of specific proper states. Therefore, the analytical expansion of the notion of feature leads to the creation of the notion of a set of its states. A set of states of a feature reflects the internal diversification, detailing and analytical complexity thereof. If a feature is treated as a variable in mathematics, then a state of a feature will be each value of said variable[7].

All possible identified or applied states make up the **set of states of an feature**: $\mathbf{S} = \{s_1, s_2, s_3, ...\}$ or $\mathbf{S} = \{s_1, s_2, ..., s_n\}$, or $\mathbf{S} = \emptyset$, which for quantitative features is called the variation range or the range. In the case of features that are quantities, specific measurement scales, units of measure and measuring systems are employed. The states of features allow more

[6] A family of sets is a set all elements of which are sets.

[7] The term "state of feature" is used in place of "value of feature", "value of state of feature" and "value of quality" to describe the result of operation of the evaluation of feature and quality (Item 4.4).

detailed research of nature, similarity, and diversification of objects of which a specific quality is a member.

Description 3.3. **State of feature depicts any possible identification of said feature in respect to objects.**

When defining quality based on the states of features, one takes into account the **second and detailed level of cognition** of objects, which occurs in the form of state of quality.

Description 3.4. **State of quality depicts a set of the states of features**,

$$\mathbf{J}_s = \{s_{c1}, s_{c2}, s_{c3}, \ldots\} \text{ or } \mathbf{J}_s = \{s_{c1}, s_{c2}, \ldots, s_{cn}\} \text{ or } \mathbf{J}_s = \varnothing.$$

Description 3.5. **State of quality of an object depicts the set of features belonging to it**,

$$\mathbf{J}^p_s = \{s^p_{c1}, s^p_{c2}, \ldots, s^p_{cn}\}.$$

Description 3.5 is based on an imperative that **at least one** state of each feature that is a member of the object belongs to the state of object's quality. In the process of assigning states of features to objects, the logical formula of the following type is used, similarly as in the case of assigning features to object: $A \vee \sim A$ (fact *A* occurs or not) and the following problem is resolved: whether individual states of features are ($s_c \in \mathbf{J}^p_s$) or are not ($s_c \notin \mathbf{J}^p_s$) members of this object. The problem of interpreting the state of quality on the grounds of the fuzzy sets theory is resolved using the membership function(μ_s) of set $\mathbf{J}_s$ to determine the membership degree of individual states of features (s_c) to set $\mathbf{J}_s$. **Fuzzy state of quality** ($\mathbf{J}_{sr}$) will then be a set of ordered pairs:

$$\mathbf{J}_{sr} = \{(s_c, \mu_s(s_c)) \mid s_c \in \mathbf{J}_s\}, \text{ and } \mu_s : \mathbf{J}_s \rightarrow [0, 1]. \quad (3.3)$$

After taking into consideration the determination of the state of feature (3.3) and state of quality (3.4), in the determination (3.1) quality will be defined as a family of sets of states of features ($\mathbf{R_S}$), as the features that the elements of quality are at the same time sets of their states ($\mathbf{S}_1$, $\mathbf{S}_2$, ..., $\mathbf{S}_n$). Therefore, the determination of quality taking into consideration the first and second level of detail of object cognition is as follows: **Quality depicts a family of sets of states of features:** $\mathbf{R_S} = \{\mathbf{S}_1, \mathbf{S}_2, \ldots, \mathbf{S}_n\}$. This means that the notion of quality, associated with general (universal) information and knowledge, is expanded in the description "state of quality", associated with specific (individual) information and knowledge.

An important qualitological issue is the determination of the object range of features, states of features, quality, and states of quality (Item 3.2). At the same time, it is assumed that the property of membership of the specified qualitative categories to object is a basis for assigning objects to a set creating the specific object range. Therefore, the **material scope of feature** ($\mathbf{P}_c$) occurring at a certain time is defined as a set of objects of which this feature (c) is a member, $\{p \in \mathbf{P}_c : F(c)\}$. **Material scope of the state of feature** ($\mathbf{P}_s$) occurring at a certain time is defined as a set of objects of which this state of feature (s) is a member, $\{p \in \mathbf{P}_s : F(s)\}$. **Material scope of quality** ($\mathbf{P_J}$) occurring at a certain time is defined as a set of objects of which this quality (**J**) is a member, $\{p \in \mathbf{P_J} : F(\mathbf{J})\}$. **Material scope of the state of quality** ($\mathbf{P_s}$) occurring at a certain time is defined as a set of objects of which this state of quality ($\mathbf{J_s}$) is a member, $\{p \in \mathbf{P_s} : F(\mathbf{J_s})\}$.

There are logical premises indicating that the thesis assuming that the features and qualities belong to objects that make up more sets of higher cardinalities than the sets of objects the states of features and qualities are members of. This results from the manner employed to determine the material scopes and rate of qualitative changes of objects. There are empirical premises which indicate that the quality of objects is characterised by a relatively lower frequency of changes than the state of object quality.

A special type of cognitive operation referred to the quality of objects is **evaluation**, based on the application of axiological **criterion of value** (feature called value) (Items 4.4 and 5.9). This operation illustrates the transition from a neutral characteristics of an object (non-valuated quality) to its axiological characteristics, including theological, ethical, aesthetic, economic, psychological, useful, and other (evaluated quality). A classical example of the quality evaluation operation is the selection and limitation of the analysed set of object features to set of features regarded as important due to the selected criterion of value (e.g., efficiency, diagnostic aspect, usefulness, effectiveness [7]). Hence the following determinations of evaluated quality and evaluated state of quality:

Description 3.6. **Evaluated quality depicts the evaluated characteristics and set of features ordered in terms of value** ($\mathbf{J}$, R_w).

Description 3.7. **Evaluated state of quality depicts the evaluated characteristics and set of states of features ordered in terms of value** ($\mathbf{J}_s$, R_w).

Using terms 3.2 and 3.5, as well as 3.6 and 3.7, the evaluated quality and evaluated state of object quality are defined in a similar manner.

Apart from evaluated approach, the treatment of object quality in the function of time is cognitively interesting. Then, the possibility of process-related (kinetic, dynamic) presentation of quality and state of object quality is acquired. Changes occurring in the set of object features create a specific **quality trajectory** in the multi-dimensional space of possible qualities. Analogically, changes occurring in the set of object features create a specific **trajectory of the state of quality** in the multi-dimensional space of possible qualities. These trajectories describe complex **process of qualitative transformations** occurring for natural and artificial reasons, to which an object is exposed in a given time period. From the point of view of humans, these processes may be divided to controllable (including controlled and non-controlled) and uncontrollable.

The general notion of feature has, in the common, theoretical, and practical activities of human beings, an indefinite and growing number of designate i.e., abstractions corresponding to the general name of "feature" (see: [55, p. 387]). The correctness of formulating designata to this term as specific portions of information regarding objects is related primarily to the level of language development as an instrument of handling information within individual scientific disciplines and fields of practice. The names of designata to the term "features" should be characterised by **adequacy, equivalence, comprehensibility, logicality, and conciseness**. These names should be then: adequate for the given object, researched phenomena and facts; explicit and semantically accurate; comprehensible for the specific group of people, logical in the aspect of logical value and relation to other names and concise in terms of notation.

Specific system of designata to the term "feature" employed in individual scientific disciplines reflect their research contexts referred to the specific portions of reality. It is legitimate to conclude that there are designata to this term that are common for many scientific disciplines and numerous fields of practice. Based on that assumption, they are comprehensible and employed by a relatively large number of people of many specialisations. Therefore, the risk of fuzziness and heterogeneity of such designata to feature occurs and it is more difficult to adopt a single semantic convention. The application of properly detailed designata to the general term of "feature" leads to the formalisation of qualitative operations and any deliberations on quality[8].

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[8] It is worth noticing that the simplified approach, wherein the designata of the term "feature" are equated with the general notion of feature, is commonly applied in academia and practice. Thus, the occurrence of a multitude and diversity of features in place of a multitude and diversity of the designata of the term "feature" is indicated. Such a common, simplified convention has also been adopted in this publication.

3.2. Classification profiles of features and qualities

Further development and putting qualitology terminology in order is related with, among others, the need for a general and universal classification and characteristics of features[9]. Such a classification consists in the formulation of a set of general criteria and, on that basis, the division of features into classes adequate to the distinguished states of said criteria[10]. The concept of the most general ordering of features is presented as seventeen classification profiles demonstrated in Fig. 3.1 (cf. [6, 29]).

Below the synthetic characteristics of individual class of features (see [17, p. 26-30]) is presented.

1. Depending on the type of relation *R* between features and objects: c *R* p, each feature c, and each state of the feature may be a member of an object in a hypothetical, proposed (actual) or postulative manner. A feature occurring as a **hypothesis** means a legitimate assumption that it is a member of a specific object. As a result of the evidentiary process, the hypothetical feature is transformed into a real feature of an object by taking on the form of **proposition** or is dismissed. The **postulative** feature is, first of all, a result of the design process, and then of the process of manufacture of a specific artificial object, thus becoming also its real feature. A specific group of postulative attributes includes features assigned to abstract objects, including, for example, works of science fiction. The first two classes are typical of the cognitive activities of humans, and the third one– of humans' creative and manufacturing activities. Therefore, one of the primary goals of each scientific discipline is to discover and formulate increasingly diversified, unknown to date features of objects that expand knowledge and causative powers of humans. In the presented classification profile, the fundamental qualitological problem is resolved, regarding the statement of the occurrence and type of membership of attributes and states of features to objects.

2. The commonly observed phenomenon of dependencies[11] between the features of a specific object or between the features of various objects justifies the division into **independent** and **dependent** features. One of the basic types of these dependencies are the **causal connection**, wherein

[9] More precisely, the designata to the term "feature" in the first, general and universal degree of classification division.

[10] Criteria are the features distinguished due to their classification, decision-making, evaluative, optimising, and other functions. Classification criteria are features and the states thereof (more generally, qualitative categories), which form the basis for classification and accordingly are members of all objects assigned to the classes.

[11] A broader research perspective should cover also other types of relations between features.

features functions as causes and/or consequences. A different type of dependencies are the **functional dependencies**. The research of dependencies between features leads to the discovery of knowledge of reality and formulation of new features. The discussed classification profiles of features is very significant for the effectiveness of controlling the qualitative transformations of objects in practice.

<table>
<tr><th>classification criterion no.</th><th colspan="4">BASIC CLASS OF FEATURES</th></tr>
<tr><td>1</td><td>hypotheses</td><td colspan="2">propositions</td><td>postulates</td></tr>
<tr><td>2</td><td colspan="2">independent</td><td colspan="2">dependent</td></tr>
<tr><td>3</td><td colspan="2">linguistic (non-measurable)</td><td colspan="2">quantitative (measurable)</td></tr>
<tr><td>4</td><td>1st order goals</td><td colspan="2">. . .</td><td>mth order goals</td></tr>
<tr><td>5</td><td colspan="2">non-evaluated</td><td colspan="2">evaluated</td></tr>
<tr><td>6</td><td colspan="2">assets drawbacks</td><td colspan="2">neutral features mixed features</td></tr>
<tr><td rowspan="2">7</td><td>maximants</td><td colspan="2">minimants</td><td>maxi-mini</td></tr>
<tr><td>mini-maxi</td><td colspan="2">fixed-value</td><td>mixed</td></tr>
<tr><td>8</td><td colspan="2">models</td><td colspan="2">results</td></tr>
<tr><td>9</td><td colspan="2">simple</td><td colspan="2">complex</td></tr>
<tr><td>10</td><td colspan="2">primary</td><td colspan="2">secondary</td></tr>
<tr><td>11</td><td colspan="2">fixed</td><td colspan="2">variable</td></tr>
<tr><td>12</td><td>single-state</td><td colspan="2">dichotomous</td><td>multi-state</td></tr>
<tr><td>13</td><td colspan="2">individual</td><td colspan="2">common</td></tr>
<tr><td>14</td><td>deterministic</td><td colspan="2">random, of known distributions</td><td>random, uncertain</td></tr>
<tr><td>15</td><td colspan="2">discreet</td><td colspan="2">constant</td></tr>
<tr><td>16</td><td colspan="2">intensive</td><td colspan="2">extensive</td></tr>
<tr><td rowspan="2">17</td><td>technical</td><td colspan="2">ergonomic</td><td>geometric</td></tr>
<tr><td>economic</td><td colspan="2">sozological</td><td>. . .</td></tr>
</table>

Fig. 3.1. Classification profiles of features

3. Due to the method employed to formulate, and the accuracy of the determination of states of features, **quantitative** (measurable, numerical) and **linguistic** (non-measurable, descriptive, verbal) features are distinguished.

Description 3.8. **A quantitative feature is such a feature to which a feature of quantity belongs.**

The membership of a feature of quantity in a specific feature means that all its states may be expressed by numbers, which, depending on the degree of measurability, create an ordered (range), uniform (interval) or absolute (quotient) scale, with the exception for numerical symbols that make up the verbal (nominal) scale[12]. The measurement of features is possible mainly as a result of the development of individual scientific disciplines. For many quantitative features, units of measurement, scales and measurement instruments have been developed and standardised (e.g., physical quantities in the SI system). Historically, one can observe steady increase of the set of quantitative features, in line with Galileo's proposition to measure everything that is measurable and make measurable what is still non-measurable. Such a process makes a steady increase in accuracy and precision in the determination of states of features possible, and therefore states of object qualities. In the semantic convention adopted in the publication **quantity is treated as a specific feature**, defining the cardinality of a set of identical elements. Adoption of such an interpretation eliminates a common view which juxtaposes quality with quantity. Therefore, it also eliminates the juxtaposition of quantitative and qualitative analysis, as quantitative analysis expresses only a certain, relatively more accurate and precise, type of qualitative analysis in terms of states of features. In the proposed approach, **quantity becomes a material, universal feature which co-creates the quality of objects** in the form of quantitative features.

Description 3.9. **A linguistic feature is such a feature to which no feature of quantity belongs.**

This means that all states of a linguistic feature are expressed as words, terms, sentences, or other symbols of a specific language, as well as numerical symbols that make up a verbal scale. The meanings of the states of these features are determined in line with semantic assumptions of the specific field of knowledge and language it uses. The states of linguistic features are characterised by lower accuracy and precision when compared with the states of quantitative features. Despite that fact, states should be formulated so that comparative analysis makes it possible to explicitly determine their **equality** or **difference**. If meeting this term is impossible, in using such linguistic features, fuzzy logic needs to be adopted to determine the **degree or similarity of difference** of their states. If such linguistic features are

[12] The characteristics of mentioned scales are presented in Item [15, p. 322-331].

adopted as classification criteria, **fuzzy sets of objects** will occur in classifications based on them. As the measurement systems develop in science and practice, linguistic features undergo the process of transformation into quantitative features. Progress in the measurability of features is also expressed in the transition in the processes of measurement from less to more perfect scale.

4. In the network of teleologically oriented actions of people, some features of objects may act as means (indirect goal) or a target (final goal) in relation to other features of the same or different objects, and, generally in the role of **goal of the mth order**. This division of features is related to the pattern of cause and effect and hierarchy of activities along with the levels of the structure of created objects. Thus, the features of objects comprising a specific activity may be ordered teleologically in the following approaches: **cause and effect**, **hierarchical** and **structural**. In the cause and effect approach, the features of the relatively higher order of goals are the ones that occur as effects, compared to features that occur as causes in the networks of causative dependencies. These networks demonstrate a chronological order i.e., a temporal allocation of cause and effect. In the hierarchical approach, features are ordered as goals according to the adopted priority criteria. The structural approach consists in ordering features as goals according to the growing complexity of the created object. The features of lower complexity elements influence the relatively more important features of elements of the directly higher complexity level, and eventually the features of the object as a whole. The discussed classification profiles of features are of primary importance in shaping the quality of activities and artificial objects, oriented on the achievement of goals of subjects.

5. Taking into consideration the axiological and anthropocentric aspect of presenting features of objects, **evaluated features** and **non-evaluated features** are distinguished. The **features of value** used in the evaluation process express the most general characteristics of the relations between subjects and objects[13].

Description 3.10. **An evaluated feature is such a feature to which a feature of value has been assigned.**

Assigning a selected feature of value to a given feature means that specific states of the feature of value are assigned to this particular feature and all states reflecting it. As transpires from the essence of the feature of value itself, it is either constant or discreet quantitative feature and the selection

[13] The specific nature of the relation between subjects in the evaluation processes originates primarily from the systems of values, needs, goals and requirements of subjects (Item 4.4).

thereof in the evaluation procedure is a material **decision-making act**. The evaluation of a specific feature according to various features of value should be assumed as an obvious possibility. The initial step in the evaluation process is to determine the constant or discreet **function of value**, which assigns the selected feature of value to the states of the evaluated feature (Item 4.4). The selection of values and the evaluation process may be **objective** or **subjective**, **standardised,** or **individual**, **formalised,** or **intuitive**.

Description 3.11. **A non-evaluated feature is such a feature to which no feature of value has been assigned.**

6. In the feature evaluation process it is assumed that the variability ranges of the features of value, depending on situation, may include both positive (positive value) and negative (negative value) portion of the numerical axis, which allows a natural and exhaustive generation of **positive**, **neutral** and **negative** assessments of the evaluated features and their states. Therefore, it is logically-founded to divide the evaluated features and the states thereof into **assets** (advantages, constructive features or states, stimulants) which bring positive value, **drawbacks** (flaws, destructive features or states, destimulants) which bring negative value, **neutral features** (inert, unimportant) which bring zero or negligible value and **mixed features** which demonstrate a diverse characteristics of values.

Description 3.12. **An asset is such an evaluated feature, all distinguished states of which have been assigned positive states of the features of value.**

$$\bigwedge_{s_i \in \mathbf{S}} w_i > 0$$

where:

s_i – state "i" of evaluated feature,

S – set of states of evaluated feature,

W_i – state of feature of value corresponding to state s_i.

Example graphs of function of asset's value (for range $\langle s_{min}, s_{max} \rangle$ of constant quantitative feature a) and discreet b) and linguistic feature for states [1, 2, 3,..., n] c)) are presented in Fig. 3.2.

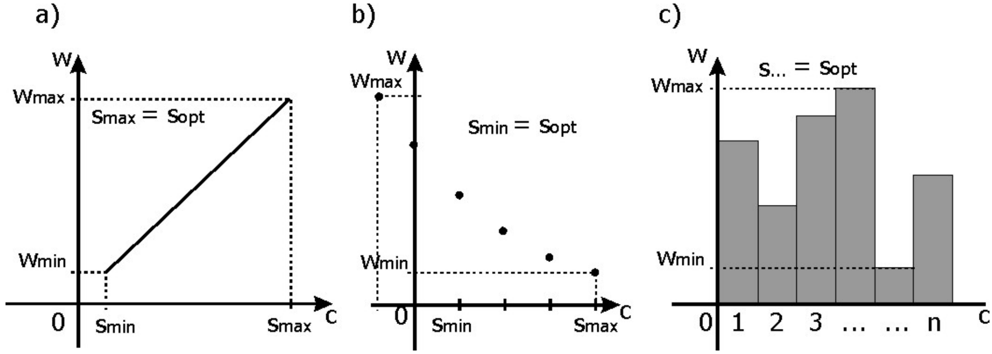

Fig. 3.2. Example graphs of function of asset's value (description in the text)

Description 3.13. **Drawback is such an evaluated feature, all distinguished states of which have been assigned negative states of the features of value.**

$$\left(\bigwedge_{s_i \in \mathbf{S}} w_i < 0\right).$$

Example graphs of function of drawback's value (for range $\langle s_{min}, s_{max}\rangle$ of constant quantitative feature a) and discreet b) and linguistic feature for states [1, 2, 3, ..., n] c)) are presented in Fig. 3.3.

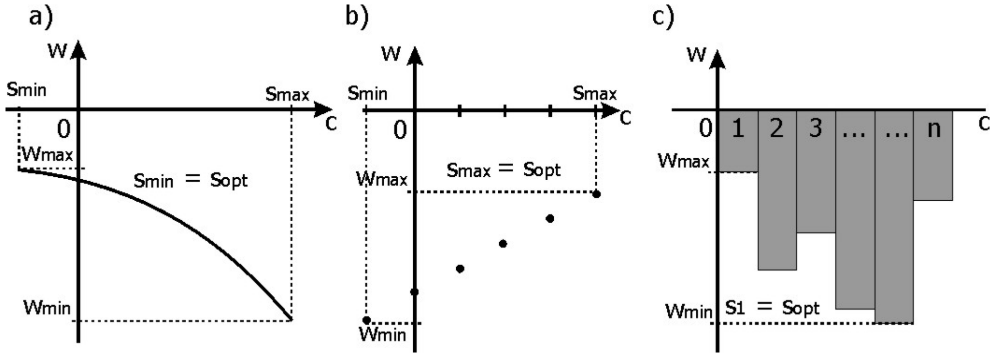

Fig. 3.3. Example graphs of function of drawback's value (description in the text)

Description 3.14. **A neutral feature is such an evaluated feature, all distinguished states of which have been assigned a state of feature of value equal zero,**

$$\left(\bigwedge_{s_i \in \mathbf{S}} w_i = 0\right).$$

Example graphs of function of neutral feature's value (for range ⟨s_{min}, s_{max}⟩ of constant quantitative feature a) and discreet b) and linguistic feature for states [1, 2, 3, ..., n] c)) are presented in Fig. 3.4.

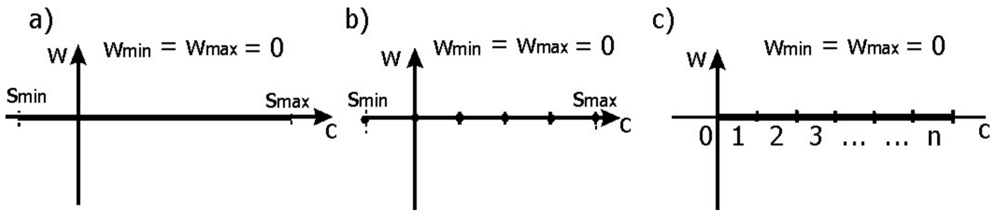

Fig. 3.4. Example graphs of function of neutral feature's value (description in the text)

If a given feature evaluated within the specific variability range does not fully meet the criterion specified in terms 3.12, 3.13 or 3.14, it means that in this variability range it is mixed. In such a case the variability range of quantitative range or individual states of linguistic feature may be divided into subranges or groups of states for which the specific quantitative or linguistic feature is an asset, drawback, or a neutral feature. The classification of features and states of evaluated features in the discussed scheme may change along with the change in the adopted feature of value. The discussed classification profile is very useful in the shaping of rational (effective, useful, efficient, economic, and working etc.) quality of objects.

7. Depending on the form of the function of quantitative features' values, maximants, minimants, maxi-mini features, mini-maxi features, fixed-value features, and mixed features are distinguished[14].

Description 3.15. **Maximant is such a quantitative evaluated feature which has been assigned a growing function of value:**

$$\bigwedge_{s_i, s_j \in \mathbf{S}} (s_i > s_j) \Rightarrow (w_i > w_j).$$

The above notation means that for any pairs of states (s_i, s_j) of a quantitative evaluated feature, the following inequality: $s_i > s_j$, implies: $w_i > w_j$ on the side of evaluation results. This means that relatively higher (lower) states of the quantitative evaluated feature correspond to higher (lower) states of the feature of value.

Example graphs of function of maximant's value (for range ⟨s_{min}, s_{max}⟩ of constant quantitative feature a) and discreet b)) are presented in Fig. 3.5.

[14] In item [29, p. 92], by using a similar classification profile, only three classes of features were distinguished: stimulants, destimulants and nominates.

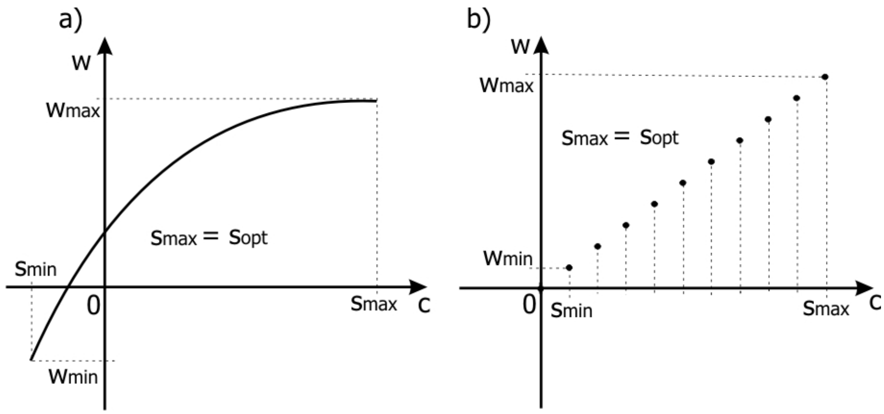

Fig. 3.5. Example graphs of function of maximant's value
(description in the text)

Description 3.16. **Minimant is such a quantitative evaluated feature which has been assigned a decreasing function of value:**

$$\bigwedge_{s_i, s_j \in \mathbf{S}} (s_i > s_j) \Rightarrow (w_i < w_j) \, .$$

Relatively higher (lower) states of the quantitative evaluated feature correspond to lower (higher) states of the feature of value.

Example graphs of function of minimant's value (for range $\langle s_{min}, s_{max} \rangle$ of constant quantitative feature a) and discreet b)) are presented in Fig. 3.6.

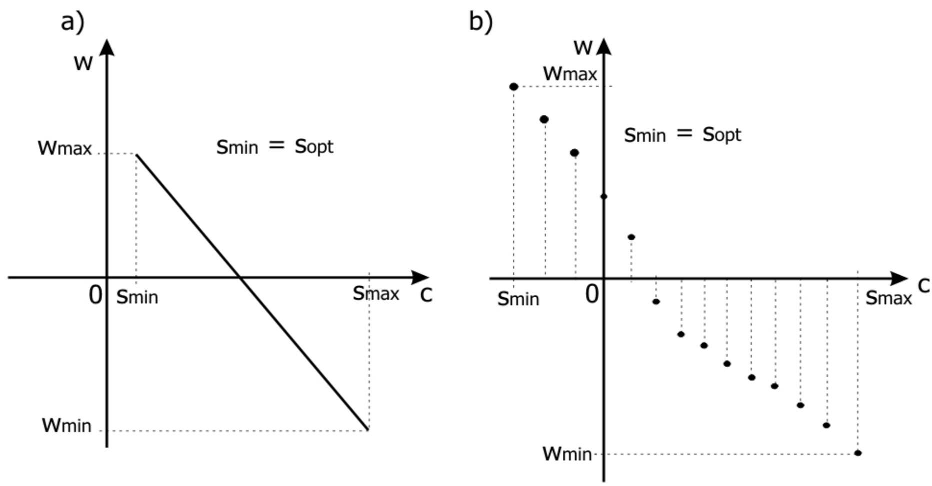

Fig. 3.6. Example graphs of function of minimant's value
(description in the text)

Description 3.17. **Maxi-mini feature is such a quantitative evaluated feature which has been assigned a growing and decreasing function of value.**

Example graphs of function of maxi-mini feature's value (for range $\langle s_{min}, s_{max} \rangle$ of constant quantitative feature a) and discreet b) are presented in Fig. 3.7.

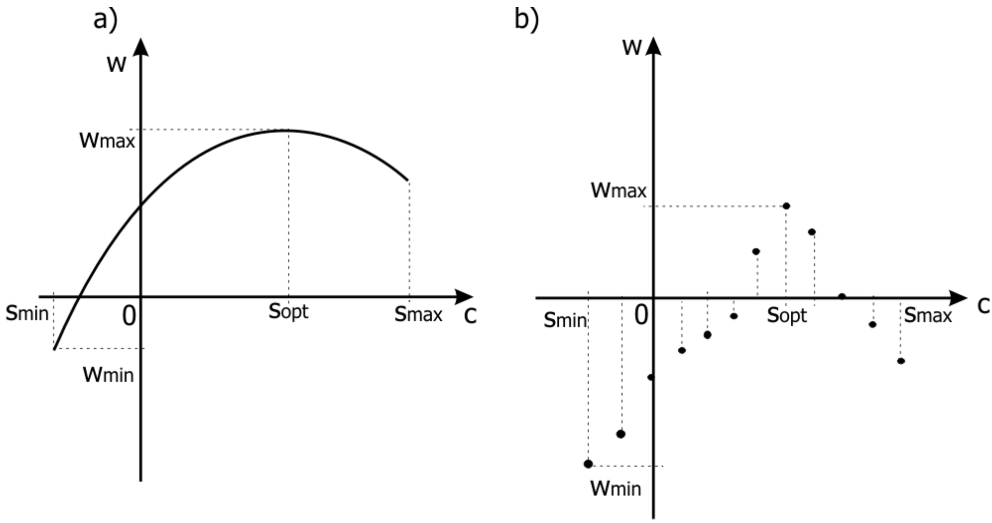

Fig. 3.7. Example graphs of function of maxi-mini feature's value (description in the text)

Description 3.18. **Mini-maxi feature is such a quantitative evaluated feature which has been assigned a decreasing and growing function of value.**

Example graphs of function of mini-maxi feature's value (for range $\langle s_{min}, s_{max} \rangle$ of constant quantitative feature a) and discreet b) are presented in Fig. 3.8.

Description 3.19. **Fixed-value feature is such a quantitative evaluated feature which has been assigned a constant function of value.**

Example graphs of function of fixed-value feature's value (for range $\langle s_{min}, s_{max} \rangle$ of constant quantitative feature a) and discreet b) are presented in Fig. 3.9.

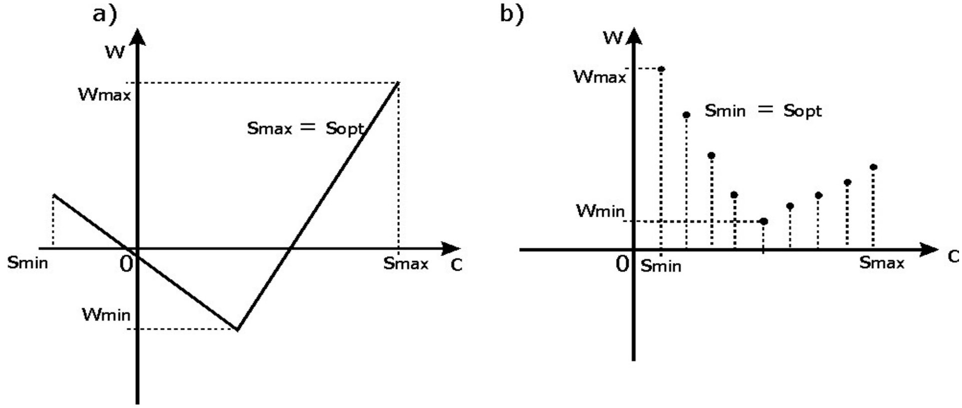

Fig. 3.8. Example graphs of function of mini-maxi feature's value (description in the text)

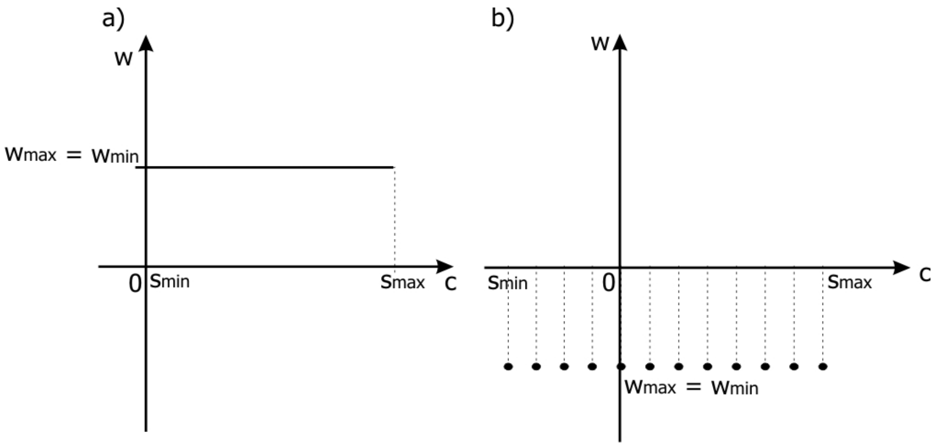

Fig. 3.9. Example graphs of function of fixed-value feature's value (description in the text)

If, in a given variability range, a specific quantitative evaluated feature does not meet just one criterion specified in terms 3.15, 3.16, 3.17, 3.18 or 3.19, it means it is a mixed feature.

For a variety of reasons, a material qualitological category is the term of the optimum state of feature.

Description 3.20. **The optimum state of an evaluated feature is such a state, for which the function of value reaches the maximum.**

The optimum state (s_{opt}) of a maximant is the right hand limit of its variability range and of minimant – it is the left hand limit of this range. The optimum state of a maxi-mini feature is located inside the variability range, and the optimum state of the mini-maxi is one of the limits of the higher value variability range. Fixed-value feature does not have an optimum state, as all considered states have the same positive, negative or zero value. The optimum state of the linguistic evaluated feature is the maximum value state (Fig. 3.2–3.9).

8. Human activities are shaped in respect of **systems of values**, **needs**, **goals** and **requirements** and are characterised by the following phases: **preparatory** and **executive**. In the preparatory phase model qualities of artificial objects are developed, which are frames of reference (qualitative goals) for the executive phase, wherein the specific qualitative results are obtained. Therefore, features and their states proposed in the preparatory phase function as a model, and after the completion of the executive stage, they function as results. An example of the discussed division are the commonly known categories of design and real quality[15] of a product. Design quality forms part of a specific product and is determined in design documents, and the real and manufacturing qualities form part of individual pieces or sets of products. Product design quality represents a uniform approach to quality, whereas real and manufacturing qualities – represent individual, diversified and average approach.

9. Taking into consideration the informational contents and the methods of formulating features, which are characterised by the occurrence of the analysis processes (disaggregation, decomposition) or synthesis (aggregation, composition), in relative schemes **simple** (elementary, analytical) and **complex features** (aggregated, synthetic) are distinguished. For instance, the dimensions (length, width, and height) of a cuboid are simple features of a geometric shape and its volume is a complex feature. A material problem arises at this point, whether or not the use of a complex feature instead of a scheme of simple features, on which this feature was developed through synthesis, is related to the loss of a portion of information. The presented example suggests an affirmative answer.

10. Having assumed a dualistic approach to quality presented in some philosophical beliefs, **primary** and **secondary features**[16] may be distinguished. Primary features result from the internal nature of objects and their

[15] In literature on qualitology, the notion of manufacturing quality understood as the deviation of real quality from design quality which occurs in the manufacturing process is more often encountered. Concurrently, certain inconsistency in the use thereof may be noticed, wherein the term "manufacturing quality" is equated with "real quality".

[16] Among others, Galileo distinguished between primary and secondary features of matter. The first ones are typical of matter itself, the latter being consequences of interactions between matter and human senses [66, p. 112].

membership in objects is objective in nature[17]. Secondary features (e.g., colour spectrum) arise and are formulated in a subjective manner, in relation to the impact of primary features (e.g., frequency of electromagnetic waves) on human senses. A special type of secondary features are the **features assigned** to objects by humans (e.g., ethical, aesthetic, economic, psychological). A hypothesis may be made that both primary and secondary features of an object result from the research of the following relation: human being *R* object.

11. Depending on the variability of states of features assigned to a specific object in the function of time, **permanent** and **variable features** may be distinguished. Permanent features are such features, the states of which, assigned to a given object, do not change or change in a negligible manner over an assumed time period. In special cases, the time period covers the entire life cycle of the object. In essence, a single-state feature is always a permanent one. Variable features are such features, the state of which, assigned to a given object, change over an assumed time period. Variable features demonstrate specific kinematics, kinetics, dynamics, and causality of changes. In controlling quality, particular importance is attached to the research of causality of changes in the states of features which occur in appropriate and natural processes of quality transformations of objects.

12. Taking into consideration the number of distinguished states, features may be divided into **single-state**, **dichotomous** (two-state) and **multi-state**. Due to the simplicity and relative ease of determining states, dichotomous features are used in communication and social practice (e.g., good–bad, cold–hot, tall–short, pretty–ugly, long–short, belonging–not belonging)[18]. In professional applications, dichotomous features are usually transformed into multi-state features. In general, sets of states of features may be unlimited and limited, indefinite and finite.

13. Assuming the cardinality of the set of objects entitled to features as a criterion, features may be divided into **individual** and **common**. An individual feature belongs to one and only one object in the discussed set of objects. Individual features and individual qualities based on them and assigned to specific subjects in the set allow differentiation and appropriate diversification in control processes. Common feature belongs to at least two objects.

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[17] In ISO 9000:2015 standards, primary features were called inherent properties.

[18] Limiting the size of a set of states of a specific feature leads to the emergence of fuzzy sets of objects created based on these states. Examples include the limitation of the size of the states of the "human height" feature to three sizes: high, average, and short, instead of using a specific measure and length scale. This means, e.g., that in many situations one may step up onto a higher level of accuracy in determining states of features and be free of using fuzzy sets of objects.

Common features are criteria of ordering, classification, and typology, as well as research and analysis of the similarity of objects within the same set. Each object in set created based on common features has common quality other than an empty set, made of common features. Taking into consideration the discussed division of features, quality ($\mathbf{J}^p$) of each object in the given set may be presented in the form of the sum of common quality ($\mathbf{J}_w{}^p$) and individual quality ($\mathbf{J}_i{}^p$) : $\mathbf{J}^p = \mathbf{J}_w{}^p \cup \mathbf{J}_i{}^p$. At the same time, individual qualities supplement common quality to the quality of each object in the given set.

Description 3.21. **Material scope of a feature is a set of objects to which this feature belongs.**

Description 3.22. **Material scope of quality is a set of objects to which this quality belongs.**

14. Depending on the characteristics of occurrence and changes in states of individual features pertinent to specific objects, considered in the function of time, and considering the cause and effect relation, features may be divided as follows: **deterministic** and **random, of a known and unknown distribution of probability**. The states of deterministic feature pertinent to an object are defined explicitly and fully (with probability of one) by an ensemble of factors taken into consideration in the analysis of cause and effect relation, and random feature takes on its states with a certain known or unknown probability below one[19]. Taking this division of features into consideration, one can speak of a **deterministic**, **random** or **deterministic and random** state of quality.

15. A property that is the number of occurring quantitative states of features of objects, allows the following division of these features: **discreet** and **constant** [51, p. 25]. Discreet features are characterised by the fact that the sets of states are finite or countable sets of states. The states of a discreet feature assume only some values which belong to a specific numerical range. Infinite or uncountable sets of states are assigned to constant features. The states of constant feature may take all values from a specific numerical range. At this point it is worth mentioning that linguistic features take on states from finite sets of states.

16. Depending on what is happening with feature, when in an object its parts are being isolated, they can be divided into: **intensive** and **extensive**. Intensive features of an object are also pertinent to parts of the object. On

[19] In qualitology, to use features and random qualities, one may fully employ the methodology of such branches of mathematics as the probability theory, mathematical statistics

the other hand, extensive features of an object are not pertinent to its parts [66, p. 159].

17. Each object may be considered with many research aspects in mind, typical, inter alia, of individual scientific disciplines or fields of practice. As a result of such an approach, it is possible to group features pertinent to objects according to research aspects of individual scientific disciplines or practical aspects. Thus, partial qualities of objects are created, as well as a specific, relatively interpreted comprehensive quality.

Description 3.23. **Comprehensive quality is the sum of partial qualities.**

This definition is general and takes into consideration the relativism of the level of complexity of the quality of objects. The assessment of the degree of complexity of quality requires that the collection of complexity criteria to be determined first, and then the conclusion to what extent each criterion is met (see p. 5.4). Research aspect which occurs in the 17th classification profile is just one of the possible criteria of comprehensible quality.

Based on the above concept of a multi-criterion classification and characteristics of features, many varieties of quality may be created. The methodological principle of creating these varieties consists in grouping similar features in subsets, according to individual criteria of classification. Examples of quality varieties created in this manner include:

- hypothetical, real, and postulated quality,
- quantitative and linguistic quality,
- non-evaluated and evaluated quality,
- model and achieved quality,
- fixed and variable quality,
- deterministic and random quality,
- primary and secondary quality,
- individual and common quality,
- intensive and extensive quality,
- physical, technical, economic, ergonomic, ecological, and useful quality.

The presented concept of terminological convention pertains to selected basic terms in general theory of quality and, surely, does not exhaustively solve the problem. Some other necessary terms will be defined further on.

3.3. Information approach to quality

The terms **quality** and **information** belong to the fundamental categories of definitions, commonly used in the lives of people and in operations of organisations. In particular, they are used to identify the needs of subjects (persons, social groups, organisations) as well as methods and means to satisfy them. All subjects have **needs for information and quality**, the meeting of which is related to all other types of needs. These terms are widespread in scientific, professional, and amateur practical operations.

In the context of qualitological issues discussed in this book, it is worth explaining what the information approach to quality consists in. Since times immemorial man has created and used the designata of a term which is now referred to as information. It is obvious to conclude that information accompanies any conscious activity of any subject. An even further reaching thesis may be formulated, that **information determines the essence of human consciousness and existence**. The adoption of such a thesis means, in practice, that in any conscious activity of subjects, information is used to conceive, **model** (illustrate) and conduct this activity. The information and decision-making processes discussed widely in management sciences, are an example of such an approach to the "subject vs information" relation. The omnipresence of the term "information" and the designata thereof results in the fact that in respect of definition, the term is quite obvious, which encourages many authors to abandon the efforts to define it.

The dynamic development of information technologies in the last few decades considerably expanded the scope of possibilities and the intensity of handling information in the operation of subjects. The point is, in particular, in the progress regarding information (including computer technologies) and telecommunication technologies which systematically increase the opportunities in the scope of acquisition, gathering, processing, storage and transmission of information. Concurrently, the awareness of subjects regarding the role and significance of information as a **valuable resource** in their activities is rising. The proper creation, acquisition and use of this resource boosts the effectiveness and efficiency of activities. This applies equally to the activity of people and organisations. The consequence of the rising awareness of the significance of information, are the ideas of **information society** and **knowledge society** [42, 57], which are promoted and developed in literature. "Information society is a society and economy, wherein information and knowledge become the fundamental production (and consumption, author's note) factor" [57, p. 367].

The premises specified above provide grounds to the comparative analysis of the terms quality and information. An additional justification of the need for such analysis is the hypothesis regarding the occurrence of a close relationship between the terms. It is assumed that the analysis will take into account the relations of similarities and differences of the conceptual scope of both terms. As the notion of quality has been exhaustively explained in previous fragments of this book, what remains to be defined is information, based on the achievements of the theory of information.

Based on the review of literature, one can conclude that the theory of information is still in its first stage of development. This is suggested by the diversity and inconsistency of presented concepts, including diverse approaches to terminology. Some authors treat information as a primary term (undefined), others formulate materially different definitions [13, 19, 26, 33, 42, 43, 47, 57, 58]. The statement of Flechtner may be an illustration of such a state: "The term information is not only the central notion in the theory of information, but also the fundamental notion of cybernetics. It is, at the same time, the most difficult term for those who want to study cybernetics in more detail. Merely a superficial review of literature shows that the term is not only defined in different manners, but also, in strict definition deriving from information theory, it seems to have a completely different meaning from that we are used to attaching to the word" [43, p. 26]. A number of authors' original attitudes in this respect are presented briefly below.

Marian Mazur distinguishes a quantitative and value-based theory of information and is composing a qualitative theory of information himself. The quantitative theory of information is dominated by the mathematically accurate category of **information quantity** expressed by a well-known Shannon's formula (see: [43, p. 15]). The quantity of information resulting from the conclusion that one of the two equally probable events occurred, called the bit, was adopted as the unit of the quantity of information. Therefore, the quantity of information expressed in bits upon the conclusion that one of the n equally probable events occurred, is expressed by a known Hartley's formula (see [43, p. 16]). Such a perception of the quantity of information does not take into consideration all situations wherein there is a need for quantitative approach to information, nor does it take into account an intuitive understanding of the term. By indicating publications which comprise a valuable theory of information, M. Mazur concludes that they pertain to the issues of the assessment of usefulness of information in solving of decision-making problems [43, p. 11].

By creating a qualitative theory of information, M. Mazur attempts to explain the essence of information, its types and what the information processes consist in. Based on the achievements of cybernetics, he stresses the importance of the transformation of messages as elements of the control process. At the same time, as a message, he understands "a physical state which is specifically different from another physical state in the control path" [43, p. 34]. The developed, original, consistent terminological system may be understood in the context of full deliberations of the author, but it is worth mentioning a number of defined terms: information, pseudo-information, disinformation, parainformation and metainformation, with stress put on the process. Common definitions of these terms mean that information is the reception of messages, pseudo-information is apparent information (lengthy, general, unclear), disinformation is false information (fictitious, withheld, mispresented), parainformation is presumed information, and metainformation is informing about information [43, p. 209]. Finally, it is worth stressing that the qualitative theory of information does not relate to the modern concepts of qualitology.

Edward Kowalczyk includes the theory of information in system theories and indicates its relations with cybernetics, statistics, and thermodynamics [33]. The relations with cybernetics are based on the role of information in control systems; with statistics –on diversity and probability of events, and with thermodynamics–on the relation between information and entropy. In information theory, entropy may be used to measure the quantity of information wherever indeterminacy, chaos, uncertainty, or disorder occurs. An important goal in the creation and use of information is to decrease, or even eliminate, these unfavourable phenomena. E. Kowalczyk uses, inter alia, the term of "information capacity of an object" which is measured with quantity of information and is proportionally dependent on the degree of complexity and sophistication of object's structure. He distinguishes an information situation in the object-observer system, which depends on object's properties, features of the observer and conditions of observation [33, p. 31]. Quite rightly, he points out that the term information has a psycho-physiological sense and concludes that "Information Theory, in its current shape, does not enter the realm of psychology" [33, p. 32]. Further on, he concludes that "... the interpretation of reality related to a certain individual may be regarded as the essence of a psychological sense of information" [33, p. 50]. One of the author's interpretations of the term information is: "Information is the realisation (or even the consequences thereof) of the essence, significance of the quantity, and scope of the order by the observer" [33, p. 33].

Bogdan Stefanowicz, inter alia, reviews various definitions and interpretations of the term information [58, pp. 13-15]. He concludes that the term information occurs in cybernetics, theory of systems, computer science, theory of communication, psychology, quantum mechanics, molecular biology, and neurology. He distinguishes three approaches to the term information that may be encountered in literature. The first one treats information as initial term (not defined). The second approach defines the term in line with principles adapted to the needs of individual research fields, e.g. using such notions as probability, entropy, message. In the third approach information is described by its features and functions. He also quotes the most general philosophical definition of information "... information is referred to as the reflection (representation) of the diversity which marks the surrounding reality (object, event, process, phenomenon)." [68, p. 13].

The **infological concept of information**[20] described by B. Stefanowicz provides interesting content [58, pp. 15-28]. According to the concept, information is the representation (description) of a specific part of reality in the mind of the observer. Also, an assumption is adopted that information is the content of a message. The description of a part of reality (representation), the analysis, interpretation, and assessment thereof depends, inter alia, on the resources of knowledge and experience that the observer has (referred to as the notional thesaurus of the observer) and on their psychophysical traits and intelligence. The analysis of the part of reality leads to isolation of objects, their features, and relations between them, taking into consideration time t. Description of object O is recorded as scheme K [58, p. 16]:

$$K := \langle O, P, t \rangle. \tag{3.4}$$

In notation (3.4) P is the predicate describing object O with regard to distinguished features or its relations with other objects that belong to a specific part of reality in time t. In the infological concept of information, language plays an important role as a tool of communication. Using language, contents carried in the communication processes are represented. However, it is noticed, that language causes reduction of content due to limitedness of terminology and notional thesaurus of the researcher ("This linguistic relativism results in the fact that language determines how we see the world." [58, p. 19]). In line with the above deliberations, information, in the infological sense is subjective (depends on the observer). Information which is not dependent on the observer is objective information, namely **information in the datalogical sense** [58, pp. 20-24]. Distinguishing information in the datalogical sense enables the use of the term information in a situation wherein a human being does not need to interpret the contents of the message. This helps i.e., to use the terms biological or genetic information. As a result, we deal with a two-fold nature of information - subjective (information that specific recipients are aware of) and objective (potential information, in general sense, for all recipients).

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[20] The infological concept of information has been developed by Swedish scholars, Bo Sundgren and Bo Langefors [42, p. 24; 35, 59].

According to the infological concept, information that is realised by the recipient of message depends on the following factors [58, pp. 22-23]:

- time over which the recipient assimilates and analyses the contents of the message,
- notional thesaurus of the recipient,
- problem and task-related context which accompanies the recipient,
- emotional state of the recipient,
- entirety of circumstances occurring at reception of message.

An opinion is expressed that the term information means a continuous (unlimited) notion. Therefore, as a noun it occurs only in singular (e.g., in English and Russian) [58, p. 27]. In Polish grammar the term information has both singular and plural forms.

The **quality of information** described by B. Stefanowicz is an interesting issue [58, pp. 93-114]. He identifies and analyses such features of information that affect the degree of its practical usefulness and increase its value. These features are regarded as desired. The desired features include [58, pp. 95-114]:

- topicality of information as sufficient conformity of information with the actual state of an object (in the adopted period, author's note),
- reliability of information resulting from the reliability and correctness of methods employed to collect and process information,
- accuracy of information, meaning the degree of proximity of acquired states of features against their actual states,
- completeness of information, meaning the acquisition of all information regarding a specific object, need or purpose (this notion is related to the term redundancy of information),
- explicitness of information dependent on the application of unambiguous language and precisely defined terms,
- comprehensibility of information which makes the information understandable to the recipient and compliant with the recipient's notional thesaurus,
- flexibility of information, as the possibility to use information by various recipients, for various purposes and in various schemes,
- relevance of information, interpreted as the degree of proximity between information and problem the recipient deals with,
- coherence of information, as a substantive, methodological, linguistic, technical, programme and organisational compliance of, respectively: elements of the message, data acquisition methods, linguistic elements, communication techniques, data formats and structures, and components of the information process.

Apart from the desired features, B. Stefanowicz enumerates also the undesired ones, such as fragmentary nature, vagueness, lengthiness, complexity, and ambiguity [58, pp. 103-109]. It may be noticed that the undesired features may be interpreted jointly with appropriate desired features as unfavourable and favourable states of properly formulated aggregated features.

Katarzyna Materska deals, inter alia, with relations between information and knowledge in the context of knowledge society and puts forward a holistic approach to the essence of the phenomenon of information, integrating views that occur in many academic fields [42]. She claims that the theory of information is a misleading name, as the fundamental notion is the quantity of information, and not information itself. She notices that in the deliberations on information, various research approaches are adopted: quantitative, psychological, qualitative, philosophical, systemic, sociological, communicative, process-related, infological, functional, historic. This diversity is most likely one of the reasons for there being four hundred definitions of the term information [42, pp. 24-25]. The reference of the theory of information to economic and management sciences results in the fact that information is interpreted as a **product** which has its manufacturer and user and may be subject to the following operations: storage, transmission, processing and market exchange [see: 64].

When analysing various definitions of information, K. Materska quotes T. Saracevic, the best known American researcher of the theory of information, who, when asked what information was, replied: "From a scientific point of view, the answer is: we don't know" [42, p. 26]. As transpires from the review of definitions conducted by the author, the creators of the theory of information took all positions possible (see: [42, pp. 26-31]). The proposed definitions of information stress primarily such aspects as the contents taken from the environment, data embedded in the message removed uncertainty, data used in actions, content assigned to data. The presented review of positions includes also the most controversial one, which assumes that information is a material being (a thing). As a result, K. Materska, referring to a number of authors, concludes that "to date there has been no good enough definition of information, or a good theory of information and knowledge" [42, p. 30]. Having reviewed the definitions of information, Wojciech Olejniczak expresses a similar opinion: "Even this scarce selection of the definitions of information shows how polymorphous the word is due to its meaning". The phenomenon of polymorphism is, here, related mostly to the fact that none of the quoted definitions corresponds to intuitive ideas regarding the meaning of the word. Each attempt at defining introduces some completely new contents to the meaning of the word. These definitions do not reveal, rather narrow down, thus darkening the sense, and increasing its semantic polymorphism, [47, p. 33].

On her deliberations, K. Materska accepts both the infological and datalogical concept of information. This is expressed, inter alia, in the specification of **properties** (permanent features) of **information** [42, p. 36-41]:

- information is objective (datalogical approach),
- information is non-material,
- information has varied importance for various recipients (infological approach),
- a piece of information describes an object taking a single feature into consideration,
- information is diverse in terms of content,
- information manifests the feature of synergy,
- information is mobile (may be reproduced and transferred in time and space),
- information is an inexhaustible resource,
- information may be processed,
- information is a durable good (not subject to wear and tear),
- information has a cost,
- information is spread unevenly in space.

Apart from properties, also the **functions of information** were specified, such as the cognitive, knowledge-building, consumptionist, notifying, decision-making, educational, controlling, innovative, meta-informative, culture-building, educative, integrating, communicative, motivational and commanding [42, pp. 41-42].

In her work, K. Materska presents the views of various authors, regarding the notion of **knowledge** and its classification sections [42, pp. 42-45] and relations occurring between such terms as sign, data, information, knowledge, and wisdom [42, pp. 49-56]. Therein she quotes one of the more popular definitions, which "... treats knowledge as general information regarding reality together with the skill to use it" and concludes that "... as yet no definition of knowledge has gained consensus in the academic environment" [42, p. 42].

The study of **artificial intelligence** is a very interesting, topical, and important research trend, as well as related to the theory of information. Artificial intelligence is related to the application of modern technologies (techniques) in information handling. These technologies aid or replace human beings in performing certain mental operations (functions) and most often assure more efficient (faster, cheaper, more accurate, more effective etc.) performance thereof. Mariusz Flasiński presents the issue of artificial intelligence taking into account, inter alia, the epistemological and psychological approaches [13]. He enumerates and describes thematic areas of mental work, in which artificial intelligence is used: decision making, conclusion drawing, problem solving, creativity, image recognition, knowledge representation, planning, natural language processing, teaching, social and emotional intelligence, manipulation and locomotion [13, p. 227].

In conclusion of the review of selected issues of the theory of information, it is worth mentioning the developing field of knowledge known as **information management** (**knowledge management**) [19, 26, 47, 57]. In this approach, information becomes the object of management and basis for decisions and, concurrently, a tool to satisfy the needs and achieving the goals of subjects. It is where, inter alia, information is classified according to selected criteria (features), such as: source, measurability, degree of formalisation, time, frequency, level of aggregation, functions, management level [19, p. 63].

In the information approach to quality, the infological (subjective, psychophysiological) concept of information is adopted. The datalogical concept of information described earlier will not be applicable due to the adopted assumption and the term information formulated on that basis. Based on that, it is assumed that **only the sources of stimuli and stimuli are objective** (including signals in the message channel, Fig. 3.10) which, by impacting the human senses, initiate thinking. On the other hand, thinking of each individual and its results are subjective. This does not, however, mean that thinking and the results thereof that are initiated with the same stimuli cannot be similar in different people. To the contrary, for instance, when using linguistic stimuli (signs) in communication, by assumption it is about the largest similarity of terms, thoughts and their products initiated by these stimuli, in all people using the language. To achieve this important goal semiotics is used, including terminology.

Taking into consideration the adopted assumption, the following description of information is proposed:

Description 3.24. **Information means the products of thought that function in human awareness, illustrate reality, and are non-material reality**.

Individual products of human thinking are **fragments** (components, parts, elements) of information.

A more detailed explanation of the meaning of the term information should begin with defining awareness. Due to the ambiguity of the term, it is assumed that **awareness** is the ability to identify and verbalise one's thoughts. In a different approach, awareness is a state of mind that occurs in time, in which a person knows that they exist and think (reference to the well-known philosophical sentence "I think, therefore I am"). E. Kowalczyk formulates an interesting sentence: "Awareness is a mirror in which the reflection of the surrounding world is probably a caricature of the objectively existing reality" [33, p. 9].

A person's thoughts depend on external and internal stimuli. Environment is a source of external stimuli and internal stimuli come from the "psychophysical space" of a person. Stimuli are physical in nature, which means that they may make an impact and be received by receptors in the human nervous system. Receptors are sensual organs equipped with sensory nerves capable of receiving certain types of stimuli such as electromagnetic, audio, chemical, force, thermal, kinesthetic, coenaesthetic and other. Commonly known human sensory organs include: sight, hearing, taste, smell, temperature, touch, balance, and pain. Impulses caused by stimuli travel in the nervous system to the brain, where they take part in mental operations. To present the matter more vividly, it may be concluded that stimuli come from everywhere whereas information is born within us. Due to the type of source, in general stimuli may be divided into two classes. One class covers those that come from components of material reality. The other class includes those that come from components of non-material reality. Some stimuli in this class include signals that are transferred in communication processes (Fig. 3.10).

Thinking is expressed in conscious operations of processing certain and creation of other abstract products (including terms and opinions). What is assumed as obvious is the statement that a condition precedent for thinking operations is **memory** which has three basic roles: memorising, storing, and recalling products of mental operations.

The thought processes are initiated by **perception** which is expressed in conscious responses of individual sensory organs to specific stimuli. The mental products of conscious response of individual sensory organs are referred to as **impressions**. Due to the type of stimuli, impressions are elementary, homogeneous **cognitive acts** referred to objects which are the sources of stimuli. Impressions may be formulated as features assigned to objects.

A complex perception is expressed in conscious, simultaneous responses of all sensory organs to all stimuli issued by a specific object. Mental products of a conscious and simultaneous response of all sensory organs are referred to as **observations** and the thought process itself – observation. Observations may be formulated as a set of features assigned to an object. The more complex the object is and the more states it may take on, the more stimuli it generates, and the more information may be created regarding the object.

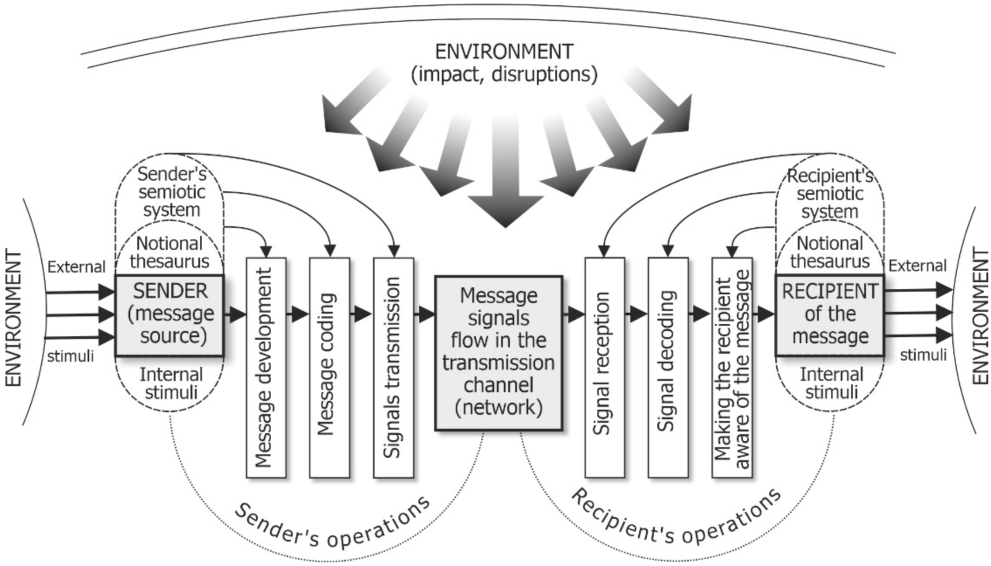

Fig. 3.10. Diagram of communication process

Ideas are yet another type of mental products. Contrary to impressions and observations, ideas may occur without a present impact of stimuli on sensory organs. Ideas occur in two fundamental manners. One of them consists in replaying (reminding) previously memorised impressions, observations, and ideas. These are reconstructive ideas. The second manner consists in creating new ideas in mental operations, which are referred to as creative ideas.

Impressions, observations, and ideas are used to create more complex products of human thought. There is a plethora of such products that are referred to as works, pieces, designs, plans, models, constructs, systems, programmes, novels, broadcasts etc.

Creativity is an extraordinary feature of the human mind. The memorised impressions, observations, ideas, and other products are objects of transformative mental operations the results of which are creative products. Creative products comprise a new reality. Creative products themselves make up new non-material reality, and some of them function as informative templates for the creation of new material reality.

According to description 3.24, information is a non-material component of artificial reality, which is characterised by the highest degree of generality and universality. This term was coined and functions exclusively in relation to the existence of man.

The above deliberations explicitly show that the products of human thoughts illustrate (represent, model) the existing and, concurrently, create new reality. A single object of imaging is an object regarded as any component of reality. Hence the extraordinary significance and exceptional role of information in human operations which aim at the cognition, creation, and transformation of objects.

One of the most important interpersonal and social relations is **communication** which covers the term **message**. The proposed descriptions of these terms are as follows:

Description 3.25. **Communication is the exchange of information between subjects.**

Description 3.26. **Message is a coherent piece of information exchanged between subjects.**

When analysing descriptions 3.25 and 3.26, it may be noticed that as a noun, the term information occurs only in singular, whereas the term message takes on both singular and plural. It should be admitted that such an approach to the term information is flawed due to the inconsistency with the grammar of Polish and the general communication practice.

Tools of communication include natural (e.g. national) and artificial (machine) languages created by man. Due to the dissimilarity of the subject and methodology of research adequate languages based on natural languages are created, also in individual scientific disciplines. The languages are used to **code information**. It is worth noticing that **information depicts reality and language codes information**, which is illustrated by the following sequence of relations:

Reality → stimuli, signals → subject → information → language → communication.

Each language is a system of signs equipped with specific semiotic values (semantic, syntactic, pragmatic) which have two basic functions:

- cognitive (model), which makes it possible to create, record and store information mappings of existing and postulated objects,
- communicative, which serves the transmission of information in messages and communication between subjects.

Conditions for effective performance of these functions include e.g. a uniform and accurate semantic convention which assures the largest possible **similarity of terms** with the sender and recipient of information that is coded and transmitted in a specific language. The syntactic aspect of language pertains to logical syntax of the system of linguistic signs that make up syntactic structures (e.g. words in a sentence, sentences in a text). Pragmatics of language determines relations between the sender or recipient of information and signs of a specific language they are using. Semiotic, in particular semantic, issues comprise a substantial, but also insufficiently developed component of both theory of information and qualitology.

Mental processes and products are externalised (verbalised) in the form of various languages created by man. Each language makes it possible to **create**, **store** on specific carriers, **transmit** through specific communication channels and mental **play back** of information in the form of notions. Thanks to these opportunities, resources of information on reality are created and used in the activities of man.

Verbal signs are a type of simple linguistic signs used in human communication: parts of speech, parts of sentence, words, names, terms etc. of which complex signs are made up: phrases, expressions, sentences, and more complicated contents. Terms, namely words or expressions that are defined, i.e. specified notionally are of particular importance. Elementary signs of language may include letters, digits, punctuation marks, graphic marks etc. In the case of the so-called body language, signs include relevant positions of the body and appearance of the person (e.g. gestures, body parts positions, facial expressions, clothing).

Information that is coded, recorded, and transmitted in the form of messages using a specific language is related to a specific **material carrier**. Recording information on a material carrier is based on its proper physical formation. This formation occurs as a signal (generally a stimuli) which, through making an impact on the recipient's sensory organs, is supposed to assure reception of information consistent with a uniform semiotic convention of the sender and recipient. Uniformity and accuracy of the semiotic convention are the features which have a direct impact on the efficiency of communication. These features are best met in a situation wherein a single subject is both sender and recipient of information.

In a general approach, communication is a multi-subject network of complex operations, comprising many diverse and inter-related elements. In a specific approach, it is referred to as a **communication process** which illustrates a model of transmission of a message from sender to recipient. A diagram of such a process is presented at Fig. 3.10.

A specific form and interpretation of elements of the communication process depends on the applied communication technology pertaining, inter alia, to the channel (network) of signals transmission. One of the conditions for the efficiency of the communication process is the consistency of the sender's and recipient's languages, including the consistency of semiotic systems and notional thesauruses. If a message is coded in a one language and decoded in another, then an appropriate linguistic translator should be applied. The use of a translator increases the risk of inconsistency of the message sent with the message received.

In the theory of information, an ambiguously defined term of **data** is often used. In the terminological convention adopted in this sub-chapter, data illustrate properly structured information which occurs in the process of information **processing**. Data comprise input of the process (input information) and output - resulting information (output information). The following description of the term data is suggested:

Description 3.27. **Data mean messages designed for processing.**

In a situation wherein machine processing occurs, data should be coded in machine language on a specific carrier and uploaded to a machine using input devices as **signals**. The physical form of signals facilitates the reception and programmed transformation thereof in machine's processing devices. Processed signals are sent to output devices, where they are decoded and presented in language the recipient understands.

Knowledge is a significant category in the theory of information [13, 19, 26, 42, 47, 57]. Knowledge is built as a result of mental operations of data processes, also aided by machine data processing (e.g. extracting knowledge from data). These are, inter alia, operations of interpretation, transformation, analysis, synthesis, selection, reasoning, and synergy. These operations result in information that is general, universal, and up-to-date in a relatively long period, pertaining to laws, regularities, dependencies, and rules occurring in reality. Therefore, knowledge occurs as a specific type of information, to which the given properties are assigned.

Based on the authorial terminological concept presented above, the fundamental category in the theory of information, is the notion of information. All other terms under the theory were defined upon that basis. Contrary to many suggested readings, definitions of terms such communication, message, data, and knowledge contain the notion of information.

The characteristics of the notion of quality in qualitology, as developed earlier, and of the notion of information in theory of information as specified in this sub-chapter, comprise sufficient grounds for the analysis of similarities and differences between these notions.

The conclusion drawn from the comparative analysis of the description of quality (description 3.1) and information (3.24) is concurrently the most important feature of the similarity of these terms – **quality is one of the form**

of information. Therefore, information in relation to quality is a more general notion, of a larger scope and with more precedence, and quality, in relation to information, is a more specific notion, with smaller scope and less precedence. Therefore, the notions of information and quality are different in terms of the following features: level of abstraction, subjective scope, and hierarchy. Hence, in the information approach to quality, description 3.1 takes on the following formula:

Description 3.28. **Quality is referred to as information in the form a set of features**.

As has been determined (Item 3.1), the term feature used in this description is understood as a coherent fragment of information. The information sense of the term features results in the fact that description 3.28 does not change the essence of the term quality included in description 3.1, but only stresses the information aspect of quality, twice. It may then be assumed that both descriptions are **equivalent**.

As results from the conducted deliberations, the terms information and quality belong to each component of reality (object) studied or created by man and are mental images (abstractions) of objects, created in consequence of cognitive or creative operations. Both information on the object, as well as the quality of object take into account the limitation of information and quality only to the information and features that are assigned to the specific object. Hence the following descriptions:

Description 3.29. **Information on an object is referred to as information that is assigned to it**.

Description 3.30. **Quality of an object is the information in the form of a set of features that is assigned to it**.

In the communication process, both information on the object, as well as the quality of the object, are transmitted as messages.

If information and quality may illustrate any object, they may also illustrate terms information, quality, information on object, and quality of object. Therefore, the following phrases are allowed: quality of information, information on quality, information regarding information on object, quality of information on object, information on object quality, quality of object quality. Obviously, the specification of information presented in the form of a feature is the state of feature.

As shown in this sub-chapter, **information quality** is a specific object of research in theory of information. An important task in the research is to develop a set of features of meaningful information, demonstrating a high level of substantive (taking into consideration the diversity of information) and objective universality (taking into account the diversity of objects it is assigned to). Such features of information may include such features as: **non-materiality, truthfulness, objectivity (subjectivity), quantity, accuracy, validity, complexity, coherence, comprehensiveness, detail, value, usefulness, explicitness, divisibility, non-expandability, permanence, novelty, diversity, mobility, relevance, reliability** [see 63]. The same features pertain also to quality, which is related to the term of quality of quality.

The set of essential universal features of information is referred to as **common quality** of any set of specific fragments of information (e.g., features). In a general approach, the isolation of fragments of information and creation of their sets is made in relation to the selection of specific objects in reality. As a result, we may speak of common quality of fragments of information which are assigned to objects in a specific set. Common quality is made up of only those fragments of information which are assigned to all objects in a given set. Each object in a given set may also be assigned with individual fragments of information which, jointly with common fragments of information, comprise full information on these objects.

The **value of information** has been included in the set of essential universal features of information. This feature results from the relation between subject and information, which shows the impact of information on meeting needs, goals, and requirements of the subject. The designata of the value of information feature may reflect the psychological, economic, ethical, aesthetic, social, ecological, physiological, and other values. The operation of valuation of a fragment of information (e.g. feature) consists in the selection of an appropriate designatum (or designata) of the feature of the value of information and assigning a specific state (or states) of this designatum (or designata) to this fragment of information. Valuation of information presented in the form of object quality has been explained in sub-chapters 4.4 and 5.9.

The **quantity of information** has been included in the set of essential universal features of information. Thus, this feature is assigned also to any fragment of information, e.g. message, feature. This also means that any fragment of information has a specific **state** of the feature of quantity assigned. Therefore, in order to use the feature of quantity, adequate measurement scales should be developed for the quantity of information.

The method of measurement information quantity indicated in this subchapter, based on the probability of events or entropy, is single-aspect and insufficient. The absence of sufficiently developed, other methods of measurement means that this is a complex and difficult problem. The postulated direction of the search for scales to measure the quantity of information consists in the use of numerical axis to represent the number of signs in a language (letters, digits, words, sentences, paragraphs, pages, graphic signs, volumes etc.) used to code a specific fragment of information, having eliminated redundancy. The application of such a measurement scales means that the quantity of information included in object quality is determined, inter alia, by the power of set of features. Such a measurement is surely imperfect and relative. These shortcomings result mainly from diverse information capacity of signs as well as diverse structure and form of languages applied. Despite that fact, even an imperfect measurement of the quality of information may be useful in exercising the cognitive and communicative function of language.

Extremely important operations of coding and decoding information using language as a tool occur in communication (Fig. 3.10). Efficiency in the application of this tool depends on the quality of semiotic system. Therefore, the selected information and quality-related aspects of the semiotic system of language are discussed in sub-chapter 6.2.

Chapter IV

BASIC QUALITATIVE OPERATIONS

4.1. Operation of determining non-evaluated quality

The initial and necessary condition for using and handling qualitative categories is their existence as abstractions which later, as a result of the application of the function of quality, are considered in relation with specific objects. The processes of creating and using these categories consist in the performance of specific operations as standard actions, which may be called qualitative operations. The results of literature studies indicate that there is a large set of operations performed on qualitative categories, in particular in quality engineering, in quality management engineering to be exact. A thesis was put forward, that on the level of the general theory of quality, the general, fundamental, and universal qualitative operations may be developed. In the process of justifying this thesis, the following six basic qualitative operations were developed: determining the non-evaluated quality, systematisation of quality, comparison of quality, evaluation of quality, quality optimisation and management.

The purpose of the operation of determining non-evaluated quality is to study the nature (essence, difference, identity, form, manner of existence etc.) of objects, considered in **a diagnostic** or **prognostic mode**[1]. The diagnostic mode is characterised with a retrospective, factual and most often objectivised approach to a specific object. The result of the application of

[1] In addition, a **postulative mode** was distinguished to determine object's quality, relevant for the operation of evaluation, optimisation, and management (Items 4.4, 4.5, and 4.6).

this mode is the objective determination of an actual, non-evaluated quality of an object, considered in the past and present tense. In the prognostic mode, the applied forecasting methods are supposed to assure the objective knowledge of the non-evaluated quality of object in the future tense. This knowledge should be characterised with the largest possible probability that it will be confirmed in a defined future.

In the case of determining a non-evaluated quality of complex objects with single or multi-level structure, it is necessary to make a decision regarding the scope of research in an alternative system of the following decision-making variants:

- study and determination of quality only of a complex object as a whole,
- study and determination of quality of a complex object as a whole and its all or selected components.

It is beyond doubt that the application of the latter decision-making variant assures considerably broader knowledge of quality (it takes into account, inter alia, qualitative synergy, see Item 5.6), but it requires much more effort. The second variant takes into account the scalable compromise solution which consists in determining the quality of a complex object as well as the quality of selected components thereof. It is worth stressing that methodological concepts developed herein, including the method-based concepts of quality determination regarding objects, are also applicable to any component thereof, as each component is, by assumption, an object.

In line with definition 3.2, the determination of quality of objects consists in the formulation of sets of their specific features taking also into account the sets of the states of these features which assure a general and specific determination of object quality. It is usually a research task which may be conducted through observation and analysis of actual processes, phenomena, events and other aspects of the studied object with or without relevant intervention of the researcher, as well as a method consisting in designing and performing relevant research experiments. The above research task may be carried out in a shorter or longer time and be related, for instance, with a specific one-off research undertaking or with a long-term development of scientific disciplines dealing with the specific class of objects. Each scientific discipline creates and systematically develops its research instruments that allow the identification of specific classes of features. Continuous and common research leads to a systematic expansion of knowledge on the quality of reality.

One of the major problems related to the determination of non-evaluated quality of an object is the determination of the cardinality of the created set of features. The pragmatics of practical operations indicate the need to apply finite sets of features. Universal premises that govern this type of solution are the research conditions, occurring at a specific place and time, regarding its purposefulness, methods, instruments, economy etc. A dependency may be noticed, which consists in the fact that along with the development of science and practice the cardinality increases, as does the complexity of the studied object quality.

A universal consequence of the operation of object quality determination consists in the adequate, qualitative information models which provide grounds for other qualitative operations. Before determining the quality of an object, one needs to put forward and verify the hypothesis regarding its existence or assume or demonstrate the possibility that it may be created.

Due to the form, explicitness, and accuracy of research in the operation of determining the non-evaluated quality of objects, the two basic methods are applied:

- **linguistic** (verbal, semantic),
- **quantitative** (measuring, numerical).

The linguistic method of quality determination is based on semiotic assumptions of the assumed language of description (natural languages, specialised languages such as engineering graphics etc.) and pertains, firstly, to the **formulation of the contents** of each feature taken into consideration. Further on, this method is used to determine the states of each linguistic feature and the necessary explanations of quantitative features, pertaining, for example, to measurements, measuring scales, units of measure. One of the major and very interesting problems in the linguistic method is the semantic fuzziness of terms in the specific language. This creates the need to use fuzzy logic in determination of quality (Items 3.1 and 6.2).

When determining the states of linguistic features, verbal measurement scales may be applied [15, p. 323]. Properties of numerical characters (designated, for instance, as a, b and c) that make up these scales, are limited to **identity** described by three axioms: $a = b$ or $a \neq b$, if $a = b$, then $b = a$ and if $a = b$, and $b=c$ then $a = c$. These are scales of the lowest measurability ratio, and numerical characters function only as **identifiers** of the states of linguistic features.

The quantitative method of quality determination consists in using the feature of quantity to determine states of quantitative features and to perform formal, including mathematical, operations on them. In many fields, e.g., in technology or econometrics, the quantitative method, when compared with the linguistic method, has relatively broader application and higher rank in determining objects quality due to the accuracy and precision of information models developed.

The known and commonly used methods of quantitative description include: **measurement, count, ranking (appraisal)**. Technology is dominated by measurements using precisely defined measures and units, as well as scales, measurement instruments and systems. There are strong relations between qualimetry and **metrology**, including technical metrology which deals with the methodology of measuring quantitative features referred to as physical quantities [48]. Due to the specified assets, the highest share of quantities in the set of features is desired[2]. A less accurate method of quantitative description is ranking, consisting in an estimated, approximate, relative, and often subjective determination of states of quantitative features. Count may apply to the determination of states of discreet integer features. Results of measurements and count are presented usually on absolute or uniform scales, and ranking results – on ordered scales.

In general, to determine statuses and variability ranges of quantitative features, ordered, uniform and absolute measurement scales are used [15, pp. 323-328]. Ordered scales are characterised by **identity** (typical of verbal scales explained earlier) and **ordering** of numbers on scales. The properties of strong ordering of numbers are determined by the following axioms: either $a > b$, or $a < b$, if $a > b$ and $b > c$, then $a > c$ (property of transition). The properties of poor ordering of numbers are determined by the following axioms: either $a \geq b$, or $a \leq b$, if $a \geq b$ and $b \geq c$, then $a \geq c$ (property of transition). Uniform scales display the properties of ordered scales, they are created based on real numbers and may have different zero points. On these scales, equal numerical ranges correspond to equal differences between the statuses of a feature which means that the **units of the measurement scale are equal**. Absolute scales demonstrate the properties of uniform scales, **natural zero** and properties defined by axioms: if $a = b$ and $c > 0$, then $a + c > b$; if $a = b$ and $c = d$, then $a + c = b + d$, $a + b = b + a$, $(a + b) + c = a + (b + c)$. These are scales of the highest degree of measurability, which allow all arithmetic and statistical operations to be performed.

One of the tasks, when determining quality, is to explicitly define, for each linguistic and quantitative feature, a set of its possible statuses, taking into account theoretical and practical premises. Many of these premises result from a specific situation and conditions in which the diagnostics, prognostics or design measures were made while determining the quality of a given object. Each element of the set of statuses of a linguistic feature has a **verbal** form, and of a quantitative feature –**numerical** and/or verbal[3].

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[2] Quantity is such a feature, the states of which are determined using measurement.

[3] For instance, the statuses of the feature of "human height" may be expressed verbally and limited to the following set: short, medium, high or may be expressed numerically using

The set of possible states of quantitative feature, also referred to as the variation range or the range, is determined through indicating the borders of the range, which are the extreme states of the feature: $\langle s_{min}, s_{max}\rangle$. In general, the range may be limited and unlimited in the length on the numerical axis of the feature, as well as a finite and infinite number of states. A discreet feature with two-sided limited range has a finite number of states, and a constant feature, or one with unlimited range has an unlimited number thereof. $\langle s_{min}, \infty)$, $(-\infty, s_{max}\rangle$ and $(-\infty, \infty)$. There is a numerous set of features that are common for objects that make up powerful sets, for which uniform, standardised ranges are applied (e.g., ranges of value in the SI system).

Two approaches are adopted for the interpretation and determination of the sets of states of the **S** feature. One approach consists in the determination of the $\mathbf{S}_m$ set of **theoretically possible** states of a feature, and the other – the $\mathbf{S}_r$ set of features that are **actually assigned** to a specific object considered within the function of time or a specific set of objects for which the given feature is a common one. The $\mathbf{S}_m$ set determined for the object includes those states of the feature that may be assigned to an object in its full life cycle or a part thereof. The $\mathbf{S}_r$ set determined for a set of objects for which a specific feature is common, include those states of feature that may be assigned to the objects of these set in an assumed time range. The statement that $\mathbf{S}_r$ set is included in the $\mathbf{S}_m$ set: $\mathbf{S}_r \subset \mathbf{S}_m$.

An example of a diverse determination of a set of possible states of feature is the determination of the set adequately to the following phases: product design, manufacturing and use of product batches. The first phase takes into account the acceptable dispersion of states of feature in the form of a fixed tolerance, the second one – actual dispersion of the states of feature assigned to the manufactured pieces of products, and the third one – actual dispersion of the states of feature in the process of using the product. The transition from the $\mathbf{S}_m$ set to the $\mathbf{S}_r$ set may lead to replacing the unlimited and infinite set of states of feature with a limited and finite one. As a result of the normalisation, specific constant quantitative features are transformed into discreet features, often with a finite set of states. In engineering and qualitative practice, such solution is grounded and useful.

As regards some quantitative features whose states make up absolute or uniform scales, one can create and apply the notion of the **level of feature**. It results from the relativization of the sates of feature regarding the selected base state of this feature. The **base state** plays the function of a reference point for the remaining states of a feature. The selection of a base state is

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units of measurement for length. In the first case, the ordered scale applies, and in the latter – the absolute measurement scale.

a decision-making problem and it should be reasonably justified. There is an option to choose more than one base state, adequately to different situations[4]. The creation of a set of feature levels provides a partial quality which may be named the level of quality. It is a type of partial quality – due to a limited share of quantitative features of absolute or uniform scale in the complex quality of a given object.

Description 4.1. **Feature level is the difference between the state of feature and the adopted base state of this feature,**

$$p_c = s - s_b \text{.}$$

Based on term 4.1, it may be easily noted that for the state of feature that is equal to the base state ($s = s_b$), the level of feature equals zero ($p = 0$), the inequality $p > 0$ is met for $s > s_b$, and the inequality $s<s_b$ implies the inequality $p < 0$.

Description 4.2. **Level of quality is a set of the levels of features,**

$$J_p = \{p_1, p_2, \ldots, p_n\} \text{.}$$

Another issue related to defining quality is the relativization of the levels of qualities in relation to the ranges of their variability (see: [29, p. 87-94]). This operation is grounded in conditions wherein, by nature or as a result of adopted assumptions, the ranges of considered features demonstrate a finite length, other than zero. The result of relativization may also be referred to as a relative level of feature or, in a simpler manner, **intensity of feature***,* and collectively – relative quality level or **quality intensity**.

Description 4.3. **Intensity of feature is the quotient of the level and the range of the feature,**

$$p_{cw} = \frac{s - s_b}{s_{max} - s_{min}} \text{.}$$

Intensity of feature is a dimensionless category, as the numerator and denominator of term 4.3 contain parameters that are uniform in terms of units of measurement and value. The category of intensity of feature gains specific properties if the minimum state of feature is assumed as base state

[4] The choice of various base states of the feature of "water level in rivers" is exemplified by emergency states of particular rivers at specific measurement locations and various zero points of Kelvin, Celsius or Fahrenheit temperature scale.

of the feature: $s_b = s_{min}$. Such a solution leads to the normalisation of this category, which is useful in the synthesis and comparative analysis of objects features and quality. This type of normalisation is referred to as **unitarisation** [6, p. 129-130] and demonstrates the following properties:

- variability range of feature's intensity is between ⟨0, 1⟩,
- **uniformisation** of a specific sub-set of features occurs (quantitative features of uniform and absolute scales) to the universal and dimensionless form of intensity of features, which, inter alia, allows arithmetic operations of addition and calculation of average intensity of features of a specific sub-set.

The above properties result in the fact that in order to put the quality and objects in order, one may formulate synthetic criteria based on normalised intensities of features of uniform and absolute scales. The arithmetic means of the intensity of such feature that occur in the k number may be used as an example of the ordering criterion:

$$p_{wsr} = \frac{1}{k}\sum_{i=1}^{k} p_{iw} \quad . \tag{4.1}$$

The arithmetic mean of the intensity of features is one of the complex features and the application thereof is grounded when it facilitates the achievement of goals of the qualitative comparative analysis of the quality of objects; it often coincides with analytical information, and the subject knows the algorithm of synthesis.

In the procedure of determining the quality of objects, two approaches may be taken into consideration:

a) **time-based** (also referred to as the diachronic approach [66, p. 187]), which consists in determining the **trajectory** of changes in individual qualitative categories (e.g., feature, intensity of feature, quality, state of quality, level of quality) regarding a specific object considered in the **function of time**;
b) **spatial** (also referred to as the synchronic approach [66, p. 187]), consisting in assigning individual qualitative categories identified in specific periods, to objects belonging to the set of objects demonstrating **common quality**.

The superposition of the above approaches reflects the two-dimensional temporal and spatial approach to determining the quality of objects in the specific set. A special case of the **static approach**, consisting in the determination of object quality in a specific period and useful in practice, occurs within the temporal approach. Due to a non-zero duration of the process of object quality determination, this period is a conventional term and in reality it is a certain period.

To conclude this sub-chapter, it is worth indicating that in the process of determining the non-evaluation quality of objects, there are two closely integrated levels of quality identification. The first level reflects the determination of the non-evaluated quality of a given object through formulating features affiliated with it and the other consists in the determination of non-evaluated state of quality by means of determining states, levels and intensity of features typical of the object.

4.2. Quality systematisation operation

The quality systematisation operation, in logical sense, is the continuation of the determination operation and it consists in performing such operations as: analysis, classification, organisation, transformation, verification, synthesis, study and the **determination** of **relations** between identified qualitative categories. One of the primary objectives of this operation is the transition from the **set-based** to the **system-based** recognition of object quality. The main purpose of systematisation is to create a comprehensive, coherent information model of quality of the studied object that also meets other requirements. This model should, inter alia, meet requirements regarding: adequacy, clarity, explicitness, detail, comprehensiveness, materiality, and information redundancy.

A multi-aspect systematisation of quality demonstrates, inter alia, the properties of the research process of analysis and synthesis. Analysis and synthesis concentrate on qualitative categories. The main purpose of analysis and synthesis is reflected by decomposition and aggregation, study of statistical dependencies, mathematical conversions, and the study of **qualitative structure** of an object. The study and analysis of qualitative relationships comprising this structure, especially in terms of complex objects, are particularly interesting in cognitive aspect.

External and internal relationships occur in the qualitative structure of an object. The complex of internal relationships includes groups of relationships between qualitative categories associated with: the object as a whole, individual components of the object, the object as a whole and with its components; various components of the object. The groups of relationships specified above include also the occurrence of many levels of complexity of the studied object. A set of external relationships is made up of relationships occurring between qualitative categories associated with a specific object as a whole, as well as with the components of its environment. Research and analysis may help in gaining, e.g., the knowledge of the relations and mechanisms of the impact made the quality of components of a specific object and the quality of the components of environment on the object's quality. The discovered relations and mechanisms describe the quality-related phenomena and regularities, which makes it possible to use them in management and control processes.

Organisation of quality consists in the selection of ordering relations and in the presentation of object quality in the form of diversely organised sets of qualitative categories. One of the basic organisation measures is the classification of an object's features according to adopted classification criteria presented in Item 3.2. As a result of the classification and other measures aimed at organisation, a cross-sectional and clear (legible, communicative, transparent etc.) object quality is created, which meets the requirements of a good information model.

Conversion of quality consists in the creation and justified transformations of the sets of various qualitative categories associated with a specific object. The transformation operations are exemplified by grounded replacement of simple features with complex ones and vice versa. Another example is the calculation and creation of sets of levels and intensities of features.

While performing quality systematisation operations, and in the final stage, verification measures may be justified. Quality verification consists in checking how the determined and systematised quality of an object meets requirements referred to the created qualitative information model. The verification results in conclusions and acceptance (if the threshold requirements are met) or taking measures to remove model's drawbacks.

One of the tasks in the verification process is to check the materiality of identified qualitative categories, particularly the materiality of features, due to the cognitive objective. Based on that criterion, features may be divided into material (included in quality) and non-material (omitted). The following criteria prove useful when determining the materiality of features (see [7, p. 34]):

- amount of information included in feature's formula,
- constitutiveness of feature, which determines the degree to which an object is different from other objects,
- objectivism and reliability of feature,
- absence of reproduction of object data included in other features,
- research and design tradition of a given field of science or practice, the competence of which a given feature belongs to,
- easy identification and observation of feature (feature availability),
- accuracy and precision of feature as a source of information about an object.

Apart from the study of the materiality of features, research should be carried out to eliminate the phenomenon of redundancy (excess of information). Primarily, it is about finding identity features, synonymic and close in meaning, and then eliminating redundant features. In the case of features that are close in meaning, the materiality of differences between the content should be studied and evaluated. If there are material differences, they should be stressed through the proper change of linguistic formulas of features. Whenever the differences are immaterial, only one feature that is close in meaning should be taken into consideration for quality.

During systematisation, an adequate, clear, and explicit quality model of an object should be developed. Adequacy pertains to objectivity and authenticity of the model, what should be confirmed by verification studies. Clarity refers to the readability and comprehension of the model by interested entities. The explicitness requirement means that there is no doubt or diversity in the interpretation of the model.

All systematising measures carried out on features and other qualitative categories should take into account real laws, phenomena, relations, and interdependencies as only then do they have cognitive sense in the system of science and assure efficient moving force in practice.

4.3. Quality comparison operation

The perception, cognition and organisation of reality use the **phenomena of similarity and diversity of objects** [61][5]. The study and determination of similarity and diversity of objects are carried out as part of quality comparison. Therefore, quality comparison operation is a cognitive operation of great importance, used to expand knowledge and introduce order to reality. It also has various and significant practical applications[6].

The conclusions regarding similarity and diversity of objects are made based on the comparison of associated qualitative categories using specific measures of similarity. A methodological assumption when developing methods for qualitative comparative analysis is a uniform treatment of all qualitative

[5] The qualitative similarity and diversity of objects are in fact two basic and general types of relationships between objects (see [70, pp. 94-100]).

[6] A commonly known example of qualitative comparisons in practice is the research of the similarity of design and actual quality ofproducts, carried out in order to determine workmanship quality. Other examples pertain to the application of comparative analysis in the military (e.g., image recognition), medicine (e.g., diagnostics, genetic code), forensics (e.g., fingerprints, speech recognition, handwriting recognition), science and art (classification, plagiarism, copies) and in many other fields.

categories, therefore non-evaluated quality, evaluated quality, the features of values and quantities, and all classes of features. This means that **each qualitative category** may be assumed as basis in comparative analysis.

The measures of similarity are different for the first (features) and the second (states of features) level of accuracy of the study of object quality and for linguistic and quantitative features. For the first level, the function of absolute measure of similarity is taken on by the **power of the set of common features** of a pair or a more numerous set of objects. The larger the number of common features, the higher the similarity of objects, and vice versa. Each feature considered common is by definition associated with every object in the studied set and should have a uniform formula. Hence a methodological tip to avoid unnecessary studies of identicalness of features of objects, consisting in the application of one and the same linguistic form when referred to each feature associated to more than one compared object.

A basic activity in the analysis of the similarity of the quality of specific objects using an absolute measure is to determine a sub-set of all common features by means of stating identicalness and association of these features to all objects. In the elementary approach, this consists in an alternative conclusion whether or not specific features of individual objects are associated also with the remaining objects of the analysed set[7]: $c \vee \sim c$ (feature of the object is or is not associated with other objects, i.e. it is or is not a common feature). The absolute measure of similarity (g_{bn}) is expressed as the power of intersection of quality $\mathbf{J}^{(n)}$ of the set of objects of the n power:

$$g_{bn} = \overline{\overline{J^{(1)} \cap J^{(2)} \cap \ldots \cap J^{(n)}}}, \text{ for objects pair } g_{b2} = \overline{\overline{J^{(1)} \cap J^{(2)}}}. \quad (4.2)$$

The analysis of relationships (4.2) shows that the states of measures g_{bn} are positive integers, with the lowest state equalling zero, and the highest state is equal to the lowest power of object quality in the set of considered objects. This means that common quality, by definition, cannot be a set of power higher than the lowest power of quality of object in the given set. The zero state of ratio does not have to mean absolute dissimilarity of objects in a given set. This happens when the similarity analysis only considers finite sets of object features and/or having a limited power, whereas in fact they are infinite and/or of unlimited power. It seems justified that in the set of objects with $g_{bn} = 0$, there may be sub-sets of objects with $g_{bn} > 0$. Similarly, the highest state of measure g_{bn} does not mean that the objects are identical.

[7] An interesting and important research problem of qualitology is the development of theoretical grounds for the comparative analysis quality of objects based on the fuzzy mathematics theory.

The function of relative measure of qualitative similarity of objects in the specific set of n power is exercised by the power quotient of intersection of objects quality and the power of union of these qualities (g_n) [28, p. 58]:

$$g_n = \frac{\overline{\overline{J^{(1)} \cap J^{(2)} \cap \ldots \cap J^{(n)}}}}{\overline{\overline{J^{(1)} \cup J^{(2)} \cup \ldots \cup J^{(n)}}}} \text{, for a pair of objects } g_2 = \frac{\overline{\overline{J^{(1)} \cap J^{(2)}}}}{\overline{\overline{J^{(1)} \cup J^{(2)}}}} . \quad (4.3)$$

The analysis of relationships (4.3) shows that the measure of similarity g_n is a dimensionless number of normalised variability range $\langle 0, 1 \rangle$. Growing states of measure show the qualitative similarity of objects belonging to a specific set and vice versa. If $g_n = 0$, no similarity occurs, in whole or in part only (due to the limited power and finiteness of the set of object features considered in the analysis of similarity, as discussed above). Analogically, the equality of $g_n = 1$ means full or only partial identicalness of objects that belong to a specific set. The indicated relativism in the analysis of similarity occurs also in relation to the possibility, and the need for diverse, in terms of power and composition, sets of features that define the quality of objects. However, a methodological tip to take into consideration the purposeful search for and discovery of common features while studying the similarity of object quality. In a situation, wherein the purpose of research is to determine differences in objects quality, the need for intended search for and discovery of individual features must be taken into consideration.

The second degree of accuracy in analysis of similarity is based on the comparison of the states of features and states of object qualities. In reference to continuous quantitative features, the empirical statement of absolute identicalness of the state of these features identified on objects, is by assumption impossible. Therefore, for practical reasons, related, for instance, with accuracy and precision of measurement systems and the occurrence of specific measurement errors, the notion of **tolerance** should be applied when making statements on the identicalness of states of such features and all states within the confines of tolerance should be regarded as identical. Such a solution is not necessary in theoretical deliberations.

In general, when comparing the states of any feature, apart from a measurement error, selectiveness in the perception of stimuli by human senses may occur, which, in the case of a continuous feature, is followed by **natural discretisation**. In psychology, the ability to recognise the minimum difference on the states of feature, is referred to as the "sensitivity threshold", in systemic thinking it is called the "grain" or "quantum of differentiation" [55, p. 162-163].

The function of the absolute measure of similarity (b) of the states of a quantitative feature located on the uniform or absolute scale is exercised by the module of the difference between given states (s_i, s_j):

$$b = \left| s_i - s_j \right| . \quad (4.4)$$

The lower the module value, the higher the probability of the specific states of feature. If the module meets the following inequality: $0 \le b \le t$ (t – tolerance in stating the identicalness of the states of feature, quantum of differentiation[8]), then, for states s_i and s_j it can be practically stated that they are identical and constitute **a common state** if they refer to different objects. If the states of feature refer to the same object but pertain to other terms, then it may be stated that they are states common for these terms.

The formula of relative measure of similarity (b_w) of states of feature takes on the form of a difference between a unit and quotient, expressing the relation of the state difference module to the feature's variability range:

$$b_w = 1 - \frac{\left| s_i - s_j \right|}{s_{max} - s_{min}} . \quad (4.5)$$

If the unitarised indicator b_w meets the following equality: $b_w = 1$, then the given states of feature, taken into account the tolerance t, are regarded as identical and if $b_w = 0$, then relatively maximum divergence of states occurs. This is a situation wherein $s_i = s_{max}$ and $s_j = s_{min}$ or $s_i = s_{min}$ and $s_j = s_{max}$.

The dependence (4.5) allows a substantially grounded synthesis consisting in the calculation of average b_{wsr} of indicators b_w for a specific n number of common features of objects. This average is a synthetic, though not complex indicator of similarities of the states of object quality (as common quantitative features of uniform or absolute scales generally comprise only a part of the full set of common features):

$$b_{wsr} = \frac{1}{n} \sum_{a=1}^{n} b_{wa} = \frac{1}{n} \sum_{a=1}^{n} \left(1 - \frac{\left| s_{ia} - s_{ja} \right|}{s_{maxa} - s_{mina}} \right) . \quad (4.6)$$

The results of the **joint** comparison of states of a specific set of quantitative and linguistic features allow a synthetic and relatively complex determination of the similarity of the states of object quality. As in the case of the

[8] The basic postulate in metrology is the assumption that the sensitivity threshold (tolerance) is higher than zero, $t > 0$ [48, p. 17].

similarity of quality analysed based on features, the fundamental activity in the analysis of the similarity of states of object quality using an absolute measure, is to determine a sub-set of all common states of common object qualities. In the elementary approach, this consists in an alternative conclusion whether or not the state of a specific common feature of an object is associated also with the remaining objects of the analysed set[9]: $s_i \vee \sim s_i$ (the state of common feature of a specific object is or is not associated to other objects, i.e. it is or is not a common state). The absolute measure of similarity G_{bn} is expressed as the power of intersection of states quality of objects in the n power set:

$$G_{bn} = \overline{\overline{\mathbf{J}_s^{(1)} \cap \mathbf{J}_s^{(2)} \cap \ldots \cap \mathbf{J}_s^{(n)}}}, \text{ for object pair } G_{b2} = \overline{\overline{\mathbf{J}_s^{(1)} \cap \mathbf{J}_s^{(2)}}}. \quad (4.7)$$

The interpretation of indicator G_{bn} and its states is similar to the interpretation of indicator g_{bn} and its states (dependence 4.2).

The function of relative measure of similarity is exercised by indicator G_n which is the quotient of the power of the intersection of sets of object states and the power of union of these sets [40, p. 60]:

$$G_n = \frac{\overline{\overline{J_s^{(1)} \cap J_s^{(2)} \cap \ldots \cap J_s^{(n)}}}}{\overline{\overline{J_s^{(1)} \cup J_s^{(2)} \cup \ldots \cup J_s^{(n)}}}}, \text{ for a pair of objects } G_2 = \frac{\overline{\overline{J_s^{(1)} \cap J_s^{(2)}}}}{\overline{\overline{J_s^{(1)} \cup J_s^{(2)}}}}. \quad (4.8)$$

The interpretation of normalised measure G_n is analogical to the interpretation of measure g_n (dependence 4.3) but pertains to the state of object quality. In complex determination of indicator G_n also the states of linguistic features are considered. The comparison of the states of a specific linguistic feature usually comes down to the application of a logical formula: $B \vee \sim B$ (identical or different states). In order to facilitate this operation, the same linguistic formulas of linguistic states of common features should be applied, as well as the same measurement scales for quantitative features referred to different objects (e.g., the same scale of temperature, length, volume etc.).

In similarity study, the qualitative identicalness of objects is, inter alia, determined based on the comparison of their quality and states of quality. On that basis, objects are deemed identical, if the following dependencies are met (the problem is explained based on two objects):

$$(\mathbf{J}^{(1)} = \mathbf{J}^{(2)}) \leftrightarrow (\mathbf{J}^{(1)} \subset \mathbf{J}^{(2)}) \wedge (\mathbf{J}^{(2)} \subset \mathbf{J}^{(1)}),$$

[9] Analogically as in the case of the analysis of the similarity of object quality, and interesting and important research issue in qualitology is the development of theoretical grounds for comparative analysis of the states of object quality based on fuzzy sets theory.

$$(\mathbf{J}_s^{(1)} = \mathbf{J}_s^{(2)}) \leftrightarrow (\mathbf{J}_s^{(1)} \subset \mathbf{J}_s^{(2)}) \wedge (\mathbf{J}_s^{(2)} \subset \mathbf{J}_s^{(1)}). \qquad (4.9)$$

The relationship of qualitative identicalness of objects has the following properties:

- is reflexive $\mathbf{J}^{(1)} = \mathbf{J}^{(1)}$, $\mathbf{J}_s^{(1)} = \mathbf{J}_s^{(1)}$,
- is symmetrical $(\mathbf{J}^{(1)} = \mathbf{J}^{(2)}) \rightarrow (\mathbf{J}^{(2)} = \mathbf{J}^{(1)})$, $(\mathbf{J}_s^{(1)} = \mathbf{J}_s^{(2)}) \rightarrow (\mathbf{J}_s^{(2)} = \mathbf{J}_s^{(1)})$,
- is transitive $(\mathbf{J}^{(1)} = \mathbf{J}^{(2)}) \wedge (\mathbf{J}^{(2)} = \mathbf{J}^{(3)}) \rightarrow (\mathbf{J}^{(1)} = \mathbf{J}^{(3)})$, $(\mathbf{J}_s^{(1)} = \mathbf{J}_s^{(2)}) \wedge$ $\wedge (\mathbf{J}_s^{(2)} = \mathbf{J}_s^{(3)}) \rightarrow (\mathbf{J}_s^{(1)} = \mathbf{J}_s^{(3)})$.

A material operation in the qualitative comparative analysis is the determination of qualitative differences between objects. Qualitative differences are determined using sets of features $\mathbf{J}^{(1,2)}$, $\mathbf{J}^{(2,1)}$ and $\mathbf{J}^{(1,2\text{-}2,1)}$, and states of features $\mathbf{J}_s^{(1,2)}$, $\mathbf{J}_s^{(2,1)}$ and $\mathbf{J}_s^{(1,2\text{-}2,1)}$ are determined in line with the following dependencies:

$$\mathbf{J}^{(1,2)} = \mathbf{J}^{(1)} - \mathbf{J}^{(2)},\ \mathbf{J}^{(2,1)} = \mathbf{J}^{(2)} - \mathbf{J}^{(1)},\ \mathbf{J}^{(1,2\text{-}2,1)} = (\mathbf{J}^{(1)} - \mathbf{J}^{(2)}) \cup (\mathbf{J}^{(2)} - \mathbf{J}^{(1)})$$

and

$$\mathbf{J}_s^{(1,2)} = \mathbf{J}_s^{(1)} - \mathbf{J}_s^{(2)},\ \mathbf{J}_s^{(2,1)} = \mathbf{J}_s^{(2)} - \mathbf{J}_s^{(1)},\ \mathbf{J}_s^{(1,2\text{-}2,1)} = (\mathbf{J}_s^{(1)} - \mathbf{J}_s^{(2)}) \cup (\mathbf{J}_s^{(2)} - \mathbf{J}_s^{(1)}). \qquad (4.10)$$

Object 1 is different from object 2 in set of features $\mathbf{J}^{(1,2)}$ and set of features states $\mathbf{J}_s^{(1,2)}$, which form part of object 1, and not object 2. On the other hand, object 2 is different from object 1 in set of features $\mathbf{J}^{(2,1)}$ and set of features states $\mathbf{J}_s^{(2,1)}$, which form part of object 2, and not object 1. Objects 1 and 2 are different from each other in set of features $\mathbf{J}^{(1,2\text{-}2,1)}$ and set of features states $\mathbf{J}_s^{(1,2\text{-}2,1)}$, which form part only of object 1 or object 2. General dependencies regarding qualitative differences $\mathbf{J}^{(x,n)}$, $\mathbf{J}^{(n,x)}$, $\mathbf{J}^{(x,n\text{-}n,x)}$, and $\mathbf{J}_s^{(x,n)}$, $\mathbf{J}_s^{(n,x)}$, $\mathbf{J}_s^{(x,n\text{-}n\text{-}x)}$ between a specific object x and jointly considered objects in a set of n power are as follows:

$$\mathbf{J}^{(x,n)} = \mathbf{J}^{(x)} - (\mathbf{J}^{(1)} \cup \mathbf{J}^{(2)} \cup .... \cup \mathbf{J}^{(n)}),\ \mathbf{J}^{(n,x)} = (\mathbf{J}^{(1)} \cup \mathbf{J}^{(2)} \cup .... \cup \mathbf{J}^{(n)}) - \mathbf{J}^{(x)},$$

$$\mathbf{J}^{(x,n\text{-}n,x)} = [\mathbf{J}^{(x)} - (\mathbf{J}^{(1)} \cup \mathbf{J}^{(2)} \cup .... \cup \mathbf{J}^{(n)})] \cup [(\mathbf{J}^{(1)} \cup \mathbf{J}^{(2)} \cup .... \cup \mathbf{J}^{(n)}) - \mathbf{J}^{(x)}],$$

and

$$\mathbf{J}_s^{(x,n)} = \mathbf{J}_s^{(x)} - (\mathbf{J}_s^{(1)} \cup \mathbf{J}_s^{(2)} \cup .... \cup \mathbf{J}_s^{(n)}),\ \mathbf{J}_s^{(x,n)} = (\mathbf{J}_s^{(1)} \cup \mathbf{J}_s^{(2)} \cup .... \cup \mathbf{J}_s^{(n)}) - \mathbf{J}_s^{(x)},$$

$$\mathbf{J}_s^{(x,n\text{-}n\text{-}x)} = [\mathbf{J}_s^{(x)} - (\mathbf{J}_s^{(1)} \cup \mathbf{J}_s^{(2)} \cup .... \cup \mathbf{J}_s^{(n)})] \cup [(\mathbf{J}_s^{(1)} \cup \mathbf{J}_s^{(2)} \cup .... \cup \mathbf{J}_s^{(n)}) - \mathbf{J}_s^{(x)}]. \qquad (4.11)$$

The methodological premises of comparative analysis and study of qualitative similarity of objects presented above, are commensurate with the studies and analyses carried out alternatively or in conjunction in the two following schemes:

- **time-based**, when a time-based sequence of changes in qualitative categories associated with individual objects occurs,
- **object-based**, when qualitative categories are dispersed in a given set of objects and the time coordinate occurs as a parameter.

In the first scheme the qualitative categories are compared and qualitative similarity and diversity of the same object are determined in the time function of its life cycle, which enriches (expands, complements) the trajectory characteristics of qualitative changes the studied object is subject to. In the second scheme the qualitative similarity and diversity of objects that belong to the studies set, which occur in selected dates indicated on the time axis.

Based on the deliberations and findings presented in this sub-chapter, it is difficult to overestimate the importance and possibility of common application of the object quality comparison operation in all fields of science and practice. This is the basic method of cognitive organisation of reality, e.g., through carrying out the classification function (see Item 6.3).

4.4. Quality evaluation operation

The evaluation operation is a precondition when making **qualitative decisions**[10]. These decisions may pertain to the creation of solutions in the design, manufacture and use of the quality of artificial objects and in the processes of evaluation and choice regarding the quality of all objects. In the evaluation operation, an **object** is the determined and systematised quality of an artificial or natural object, a **result**– is the evaluated quality of the object and the **objective**– is to assure data necessary to make qualitative decisions.

The **postulative mode** of the determination of artificial objects is related to the evaluation operation. This mode reflects the activities and decisions of an entity which relate to the design quality and conformity quality of the created and/or manufactured object. In the postulative mode, the determination of artificial object quality is preceded by an objectified, and often subjective formulation of evaluative premises, e.g., needs, an ensemble of requirements, assessment criteria, goals. By assumption, the postulated quality of artificial object should take into account these premises, and therefore, e.g., assure the meeting of needs, requirements, and assessment criteria, as well as contribute to the achievement of goals. The application of postulative

[10] Qualitative decisions mean choices (decisions, settlements) regarding object quality.

mode in the design, construction, programming, management, manufacture, and other activities, allows the determination of design or real evaluated object quality. In the life cycle of an artificial object, the design quality determines, prospectively, the real quality of manufactured copies.

The statement that the creation of postulated quality requires the evaluation operation, and object quality optimisation operation, should be assumed as obvious (Item 4.5).

In an analytical approach, evaluation means the operation of function-based assignment of the states of selected **feature of value** to states of the analysed qualitative category assigned to a specific object. This assignment results in the determination of specific states of the feature of value which correspond, inter alia, to features and states of features, levels, and intensities of features, as well as states, levels, and relative levels of quality. In consequence, it is possible to achieve **value-based organisation** of sets of elements of qualitative categories specified above based on the evaluative relation of R_w[11]. This possibility expresses one of the goals of evaluation, presented in the form of the following sets, organised in terms of value, and comprising the comprehensive **evaluated quality of object**:

- object quality, $\{\mathbf{J}^p, R_w\}$ – set of features organised in terms of value,
- states of individual features, $\{\mathbf{S}_1, R_w\}, \{\mathbf{S}_2, R_w\},...,\{\mathbf{S}_n, R_w\}$ – sets of states of each feature of the n power set, organised in terms of value,
- state of object quality, $\{\mathbf{J}^p, R_w\}$ – set of features organised in terms of value,
- states of object quality, $\{\{\mathbf{J}_{s1}^p, \mathbf{J}_{s2}^p, ..., \mathbf{J}_{sn}^p\}, R_w\}$ – set of states of quality of the n power, organised in terms of value,
- level and relative level of object quality, sets of levels and intensities of features of a given set of features assigned to an object, organised in terms of value,
- levels and relative levels of object quality, sets of levels and relative levels of quality of a given object, organised in terms of value.

Evaluative relation R_w transforms specific sets of qualitative categories into sets organised in terms of value based on growing or decreasing states of assumed feature of value, assigned to individual elements of these sets.

Upon the application of the evaluative relation with regard to specific qualitative categories associated to objects of set **P**, this set is transformed into a set of objects organised in terms of value: $\{\mathbf{P}, R_w\}$. This set is particularly useful in comparative analysis of various objects and on making quality-related decisions. It allows, e.g., the shaping of object quality, which assure

[11] The relation R_w of the value-based organisation of qualitative categories belongs to the ordering relations class (see [70, pp. 98-99]).

increase or decrease in value and the selection, out of a set of objects, one of the highest quality value. All the sets of qualitative categories, organised in terms of value and associated to objects, provide an informative basis for decision making processes in which the specific feature of value was assumed as the **selection criterion**[12].

The features of value, by nature, are characterised by relations that occur between people and organisations as subjects of activities and objects in a situation, in which they analyse the relations of objects with own **systems of needs**, **goals** and **requirements**. The essence of these relations is expressed in the level of adequacy of non-evaluated quality of objects relative to the specific needs of certain subjects and the goals and requirements that result from them. It transpires from the above, that objects occur as measures conditioning, sufficiently, or necessarily, directly, or indirectly, fully, or partially, the meeting of specific needs, achievement of set goals and meeting of formulated requirements.

The above premise suggest that it is possible to assume the **effectiveness** of meeting needs, achieving goals and meeting requirements as a **general**, **universal,** and **primary** feature of value, employed in the operations of object quality evaluation.

In the process of decomposition of a feature of value formulated in that manner, one can isolate and systematise fundamental features of values and name them a **system of values**. The human system of values is characterised by diversity and variability, adequately to the diversity and changes in the civilisational and cultural development of humanity.

"Effectiveness", treated as a feature, is associated with any activity, and means the **level of achieving postulated results of an action**, which, in a broad sense, include: meeting of needs, achievement of goals and meeting of requirements. If the results of actions are analysed in qualitative terms with regard to specific objects, the effectiveness of the action will be measured by the **level** (degree[13]) **of conformity between the postulated** and **achieved quality** of these objects.

The application of the term "effectiveness" as the name of a universal feature of value makes the evaluation of the quality of a specific natural or artificial object based on the following scheme of binomial relation R_w:

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[12] For instance, this is important in marketing practice while designing and differentiating product quality and while choosing products in purchase processes, based on the value of their quality. During purchase, it is most often the selection of a product of required quality, from the set of products that are functionally replaceable (substitutes).

[13] It is assumed that the degree of conformity determines the discreet form of conformity level.

$$\left\{\begin{array}{c}\text{Categories}\\ \text{of non-eval-}\\ \text{uated object}\\ \text{quality}\end{array}\right\} \quad \begin{array}{c} Rw \\ \Leftrightarrow \\ \downarrow \\ \textbf{Effectiveness} \\ \text{of meeting needs,} \\ \text{achieving goals, meet-} \\ \text{ing requirements}\end{array} \quad \left\{\begin{array}{c}\text{Schemes of}\\ \text{needs, goals,}\\ \text{and require-}\\ \text{ments}\end{array}\right\} \qquad (4.12)$$

If the needs, goals, and requirements were formulated in a qualitative multi-dimensional space, then the notion of effectiveness should be referred to each dimension therein and/or its synthetic characteristics[14]. The individual needs, goals, requirements, and their qualitative characteristics may represent various types of values, among which the following values should be mentioned: useful, cognitive, praxeological, economic, psychological, ethical, and aesthetic.

In using effectiveness as a universal criterion of the evaluation of object quality, two characteristic extreme states can be observed:

1) **maximum**, which means full (total, relatively perfect, comprehensive) meeting of needs, achieving goals and meeting requirements; expressed by the number 1 in the case of the unitarisation of this criterion;
2) **minimum**, which means total failure to meet needs, achieve goals and meet requirements; expressed by the number 0 in the case of the unitarisation of this criterion.

The basic element of the objects quality evaluation operation are the **functions of value**, which explicitly map the states of specific qualitative categories (e.g., features) in the states of selected features of value. The general notation of the function of value is as follows:

$$w_j = F_{ji}(k_i) \text{ or } F_{ji} : \mathbf{K}_i \rightarrow \mathbf{W}_j \qquad (4.13)$$

where:

F_{ji} – function of value of the ith qualitative category for the jth feature of value,

w_j – jth feature of value,

k_i – evaluated, elementary or collective ith qualitative category which is an argument of a function (e.g., feature, quality, state of quality, level of quality, relative level of quality),

$\mathbf{K}_i$ – set of states of the ith qualitative category,

$\mathbf{W}_j$ – set of states of jth feature of value.

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[14] It should be stressed that when using the categories of needs, goals, and requirements, one may fully use the qualitative approach, as they are, in general sense, objects in the presented concept of qualitology.

A prerequisite to apply dependence (4.13) is the formulation of the function of value adequate to the specific situation of evaluation. In order to meet this requirement usually research and analysis are needed, demonstrating the actual influence of specific qualitative categories on certain features of value. Based on the results of said research and analysis, the discovered dependencies are approximated using logical reasoning and employing a numerous set of standard forms of mathematical functions.

The review of quality engineering with regard to the function of value indicates frequent application of a linear, polynomial, product, and power function [28]. The forms of the function of value for features allow the classification of all features in the following scheme: assets, drawbacks, neutral and mixed features, as well as quantitative features in the following scheme: maximants, minimants, maxi-mini features, mini-maxi features, fixed-value features and mixed features (Item 3.2). The proportion of the number of assets to the number of drawbacks allows a preliminary, estimated evaluation of the quality of each object.

Each feature of value is, by assumption, a quantitative one, for which an ordinal, uniform or absolute measurement scale should be created. Therefore, the feature of value occurring in dependence (4.13), as any quantitative feature, is subject to transformations which lead to determination of a unit of measure, variability range, feature level, intensity and unitarised intensity of feature (Item 4.1). Therefore, the feature of value in dependence (4.13) may, for example, occur in the form of unitarised intensity of variability range $\langle 0, 1 \rangle$.

As a result of an evaluation operation (dependence 4.13), a specific qualitative category k_i is transformed into **an evaluated qualitative category** k_i^w, which occurs as a set ordered pairs:

$$k_i^w = \{(k_{si}, F_{ji}(k_i) | k_{si} \in \mathbf{K}_i\} \tag{4.14}$$

where k_{si} – state of ith qualitative category.

For one of the basic qualitative categories, such as the non-evaluated quality of object $\mathbf{J}^{np}$, its transformation into an evaluated quality of object $\mathbf{J}^{wp}$ consists in the creation of the following set of ordered pairs:

$$\boldsymbol{J}^{wp} = \{(c_i^p, F_{ji}(c_i)) | c_i^p \in \boldsymbol{J}^{np}\}. \tag{4.15}$$

The application of the function of value leads, by means of an ordering relation, to the value-based organisation of sets of analytical states of qualitative categories associated to an object, which provides grounds for the decision regarding the states of these categories. However, there is also the need to make decisions regarding collective and comprehensively considered qualitative categories associated to an object, such as quality, state of quality, level of quality, relative level of quality. The meeting of this need is based on the development and employment of adequate **synthetic (aggregated) qualitative categories and functions of value***.* The main principle in the creation of such functions should be to take into consideration the results of evaluation operations regarding individual analytical categories. In the existing solutions to the problem, a dominating form of the synthetic feature of value and function of value is the **sum** W_{k1} or **arithmetic mean** W_{k2} of the value of analytical categories occurring in the n number, which is, in general, as follows:

$$W_{k1} = \sum_{l=1}^{n} F_{ji}(k_{il}) \quad \text{or} \quad W_{k2} = \frac{1}{n}\sum_{l=1}^{n} F_{ji}(k_{il}) . \qquad (4.16)$$

The most useful, in practice, due to the common nature of decisions regarding the designed state of quality of artificial objects and the choice of the best object in the group of functionally replaceable objects, is the synthetic function evaluating the states of object quality and states of quality of functionally replaceable objects. In line with the first dependence (4.16), the values of states of object quality or values of states of replaceable object quality are the sum of values of states of all features of each evaluated object that were taken into consideration. According to the second dependence (4.16), the evaluation and value-based ordering relation are based on the average value of states of features. The synthetic features of value W_{k1} and W_{k2} may also occur as a unitarised intensity of variability range of $\langle 0, 1 \rangle$.

The specification of the function of value and the evaluation of quality is considerably facilitated by the replacement of relation *Rw* (4.12) with *Rwz*:

$$\left\{\begin{array}{c}\text{Categories of}\\ \text{non-evaluated}\\ \text{object quality}\end{array}\right\} \begin{array}{c} Rwz \\ \Leftrightarrow \\ \downarrow \\ \textbf{Similarity}\end{array} \left\{\begin{array}{c}\text{Model of evalu-}\\ \text{ated object qual-}\\ \text{ity}\end{array}\right\} \qquad (4.17)$$

The design of models of evaluated quality of objects is based on an assumption that they should assure legitimate maximisation of the effectiveness of meeting specific needs, achieving goals and meeting requirements. The interpretation of the level of excellence of models may be related to theoretically allowed conditions and then the **ideal models** may be created; it may also be related to practically attainable conditions and thus **real**

models may be created; as well as to reasonably justified conditions and thus **reasonable models** may be created, and to conditions that are best in specific decision-making situations and thus **optimum models** may be created. Therefore, the relativism and variability of models, as well as their relative excellence. Basically, the process of creating the model of evaluated object quality consists in choosing a set of features and their states desired with regard to needs, goals, and requirements.

Due to the manner and degree of specification, two varieties of models may be distinguished in the model of hypothetical object:

- **functional models**, comprising the breakdowns of features and their states, assuring relatively excellent performance of specific functions, which leads to meeting certain needs and requirements by potential objects designed according to these models,
- **object models**, comprising the breakdowns of features and their states which directly constitute relatively excellent objects.

The term functional notion is based on the known method of value analysis, it assures considerable freedom to the designer and may lead to the creation of a large set of artificial objects considerably diversified in terms of quality. In essence, the functional model determines a relatively excellent quality of a set of functions that potential objects need to meet. On the other hand, the object-related model clearly directs design solutions, thus limiting the freedom of designers, it generates directly a specific type of objects and is realised on a smaller set of objects which are characterised by high similarity.

Among many sources of information useful in the creation of object quality models, attention should be drawn to: transnational, national, industry and company regulations, technical documentation, warranty and guarantee terms, patent certificates, quality acceptance terms, licence solutions, requirements taken into consideration in attestation and awarding quality marks, results of experimental research, documentation of innovation and technical progress, expert opinions and professional academic writings. Sometimes, specific products of manufacturers regarded as global or regional leaders are directly assumed as quality models.

Practical usefulness of models in quality evaluation depends, inter alia, on their complexity, objectivism, up-to-datedness, and fields of application. A larger scope of application and durability is demonstrated by functional models rather than objective and real rather than ideal. Due to permanent changes in conditions, models should be continuously updated. Objectivism of models assures the application of scientific principles in the development process. In general, models represent specific and commonly desired maximalist quality standards of objects.

Having models in the process of the evaluation of object quality makes it possible to determine the **similarity** (distance, metrics) of this quality to the model quality and then to use this value to formulate the analytical and synthetic function of value. The basic task of models is to act as a point of reference in the processes of evaluation and to determine the directions of improvement of the quality of artificial objects (Item 5.10).

It is worth drawing attention to the phenomenon of the **relativization** of the results of the evaluation of object quality, which mainly results from using various features, functions, and models of value. The relativism indicated above results also from the right of an individual to subjectivity in determining ones needs, goals and requirements. Such an assumption results in the fact that a specific, objective, and non-evaluated object quality may be associated with many diverse evaluated qualities (Fig. 5.3)[15].

4.5. Quality optimisation operation

The optimisation operation aims to determine and apply best solutions to quality-related problems and, by nature, pertains to the quality of designed (created, improved, constructed, planned, postulated etc.) and then manufactured objects. It is obvious to state that the basis for this operation is the quality evaluation operation. This statement results from a legitimate assumption of features of value as universal optimisation criteria. It transpires from the above that the object of the optimisation operation is the evaluated quality of artificial objects.

The optimisation of the quality of artificial objects pertains mainly to the following types of **quality-related decision-making problems** (see [39]):

- determining the power and specifying the optimum set of features of an artificial object,
- determining the optimum state of design quality of artificial object through the choice of optimum states of features,
- determining the optimum state of conformity quality of an artificial object through the choice of optimum deviations of the actual states of features from the designed states of features,

[15] An example of such a situation in practice of economic evaluation of quality is the diversity of the price of product of specific design and manufacturing quality, sold to various customer segments in diverse market conditions.

- selection of an object of optimum quality out of the set of specific objects, in particular out of the set of functionally replaceable objects (substitutes).

The quality optimisation operation conditions the occurrence of at least two solutions to the qualitative decision-making problem and one selection criterion. In the general quality optimisation model and solution of the above decision-making problems, four elements may be distinguished [39, p. 54-58]:

1) **Quality evaluation model.** This model comprises: universally identified need and resulting specification of detailed goals and requirements, selected features of value or developed quality model of an artificial object, as well as specific functions of value (Item 4.4).
2) **Decision-making variables**. These are qualitative categories referred to a specific object or objects belonging to a specific set, adequately to the above mentioned types of quality-related decision-making problems.
3) **Limitations**. They define the theoretical and/or practical boundaries of the area of acceptable solutions to the quality-related decision-making problem. They result mainly from objective realisation conditions for an artificial object, occurring in a specific system of resources, space, and time. Limitations may also be formulated directly on decision-making variables and result from legal regulations, ethical grounds, standards adopted etc.
4) **Optimisation criterion** (objective function). In the model, this criterion plays the role of a function evaluating the set of acceptable solutions **D** and transforms it into a set organised in terms of value: $\{\mathbf{D}, R_w\}$. The assumption regarding the assuming of relations and functions of value (4.12), (4.13), (4.18) and (4.19) as a **maximised** criterion of quality optimisation is fully grounded. The consequence of these dependencies is, by nature, that the selection of the optimum solution out of the set of acceptable solutions of the quality-related decision-making problem is based on the principle of searching for the maximum of objective function. This means that the highest value solution to a quality-related problem is selected.

Assuming the range of optimisation of artificial object quality as basis, the following can be distinguished:

- **complex optimisation**, covering all qualitative categories associated with an object which are deemed significant and which provide an exhaustive range of qualitative decision making variables,
- **partial optimisation**, comprising a specific subset of qualitative categories regarded as significant and associated to an object, which comprise a deliberately limited scope of qualitative decision-making variables.

Taking into account the number of criteria considered in the optimisation of a solution to a specific qualitative decision making problem, the following can be distinguished:

- **single-criterion optimisation (sub-optimisation)**, based on one criterion and one optimisation model,
- **multi-criterion optimisation (poly-optimisation)**, based on many criteria and many optimisation models.

The formulas of the function of value (4.13) and (4.16) are adopted as optimisation criteria and assume the occurrence of **value-based substitution of quality**, which means the value-based replaceability of specific qualitative categories with other (decision making variables in optimisation model). Value-based substitution consists in the compensation of smaller values of specific qualitative categories with higher values of others. It results in that any state, which means that also an optimum state, of the criterion of optimisation may be achieved using various combinations of a given object's quality or various combinations of the quality of functionally replaceable objects. The phenomenon of value-based qualitative substitution is presented in Figure 4.1 and in the following equation:

$$W_{k(1)} = W_{k(2)} = W_{k(3)} = ... = W_{k(x)} \qquad (4.18)$$

where: $W_{k(x)}$ – identical state of the synthetic criterion of optimisation (synthetic feature of value) for specific sets of combinations $\{1, 2, 3, ... , x\}$, optimised or evaluated qualitative categories $\{k_1, k_2, k_3, ...k_n\}$.

If the value-based substitution pertains to a deliberately determined state $W_{k(a)}$ of a specific synthetic criteria of optimisation, then the equality of the value of various combinations of quality and states of quality of a specific object or quality and states of quality of functionally replaceable objects may be referred to as **value-based equifinality of quality** of this object or functionally replaceable objects. If the same optimisation criterion and form of the objective function has been applied, then the phenomenon of a value-based substitution and equifinality may be considered also in the set of various objects, not just functionally replaceable. The phenomenon of value-based equifinality is illustrated by the following equation:

$$W_{k(a)} = Wk_{(1)} = W_{k(2)} = W_{k(3)} = ... = W_{k(x)}. \qquad (4.19)$$

Taking into consideration the value-based substitution and equifinality in the quality optimisation operation means that the determined qualitative optimum solution may be hypothetically achieved as a result of the application of various, but not any, quality, and state of quality of a specific object. This expands the potential and has a positive impact on the conceptual freedom of designers.

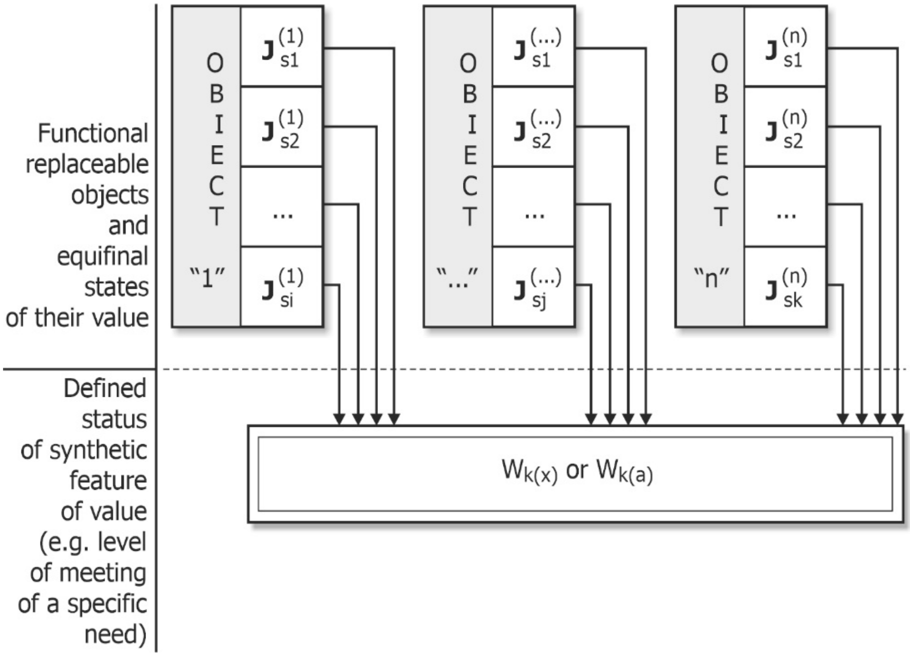

Fig. 4.1. Phenomenon of value-based substitution and equifinality of object quality

4.6. Quality management operation

Currently the quality management operation is surely the most **complex**, **common,** and **important** qualitative operation[16] in practice, and, at the same time, the best organised and developed in quality engineering. This state of affairs was a consequence of a pressure of needs and expectations, mainly of organisations, in particular enterprises. The creation of theoretical grounds for practice of quality management should be based on science, combining adequately the achievements of qualitology and science of management. The result of such an approach should be a specific theory of quality created under the name of "quality management theory". The

[16] Due to abundant available literature on quality management, this book will present quality management issues adequately to the specific approaches typical of the general theory of quality.

development of this theory is a synergic process, consisting in the study, analysis, synthesis, mutual adaptation, and development of relations between quality and management issues in organisations. The idea of these relations is presented in Figure 4.2.

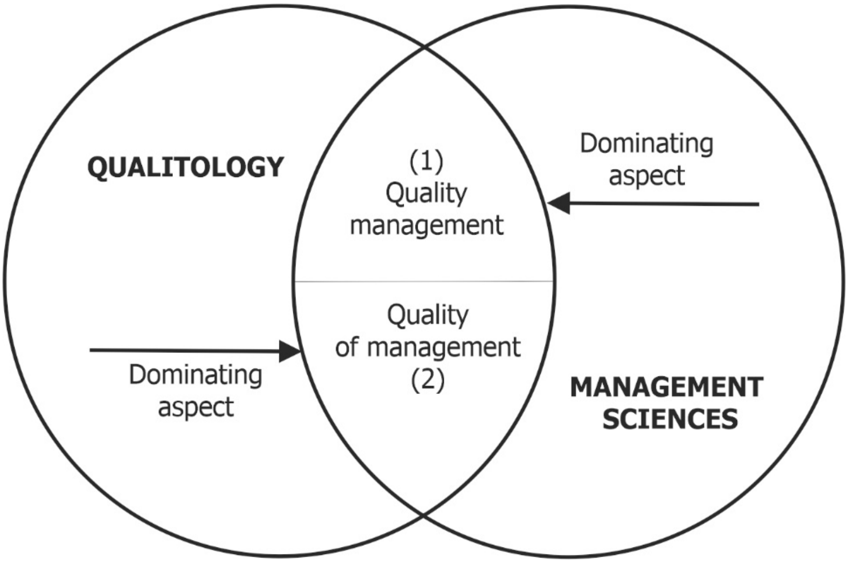

Fig. 4.2. Relation of qualitology with management sciences

The term quality management is created as a result of a logical combination of the management category with quality categories. The sense of this combination is in the reference of the management function to quality, which gains the status of a specific **managed object (system)**. It is hard to assume that spontaneous object of practical management activities could comprise abstractions, which include qualitative categories. Therefore, in defining and using the term of quality management, one should identify a class of objects entitled to this quality. The general and universal formula of such a class of objects in management systems is represented by the category of a managed system[17]. Hence the following term of quality management [17, p. 100]:

Description 4.4. **- Quality management is the performance of management function in relation to the quality of a managed system.**

[17] In qualitological approach, managed systems constitute an isolated class of objects.

Quality management understood in this manner occurs within the organisation's management system, and its essence lies in the qualitative approach to the managed system. As usually the managed system is a whole which can be structured, quality management pertains both to the quality of managed system treated as a whole and the quality of its internal components. Therefore, the general scope of quality management is determined by the range and structure of the managed system.

At this point it is worth signalling the possibility to refer qualitative categories to management and to develop the term "quality of management" (Fig. 4.2 and 6.5). In this phrasing, the term "management" identifies a certain class of objects in the super-class of objects referred to as actions, which are associated with quality as all other objects. Therefore, the qualitological concepts developed herein also refer to the quality of management. For instance, as regards quality of management, elementary qualitative operations of determination, systematisation, comparison, evaluation, and optimisation may be carried out.

For a general, universal, and systematised expansion of quality management operation an illustrative management system model will be used, which in a cybernetic approach is presented in Figure 4.3 (see [17, pp. 99-107]).

A managing subsystem controls quality management, and its consequences apply to the managed sub-system, other sub-systems in the organisation, as well as its surroundings. These consequences spread through mutual, material, energy, and information interactions. The sets of mutual interactions include feeds, which, by assumption, are beneficial (positive) for the organisation and/or surroundings, as well as disturbances, which are negative. Figure 4.3 presents the feedback between the managing sub-system with the managed sub-system (both sub-systems have been presented as mutually isolated systems) and with the organisation's surroundings. These feedbacks occur as [17, p. 101-102]:

- **management signals** generated by the sub-system managing quality in an organisation during the performance of management functions and affecting the quality of the managed sub-system as well as the quality of the output and input function,
- **management feedback** regarding the actual quality of the managed sub-system, in particular actual quality of executive measures, and the actual quality of its input and output functions necessary to make qualitative decisions, and then to transmit management signals in the next management cycle, as well as for adequate shaping of external impacts directed mainly to external feeding, cooperating and competing organisations in order to reach the required input quality,

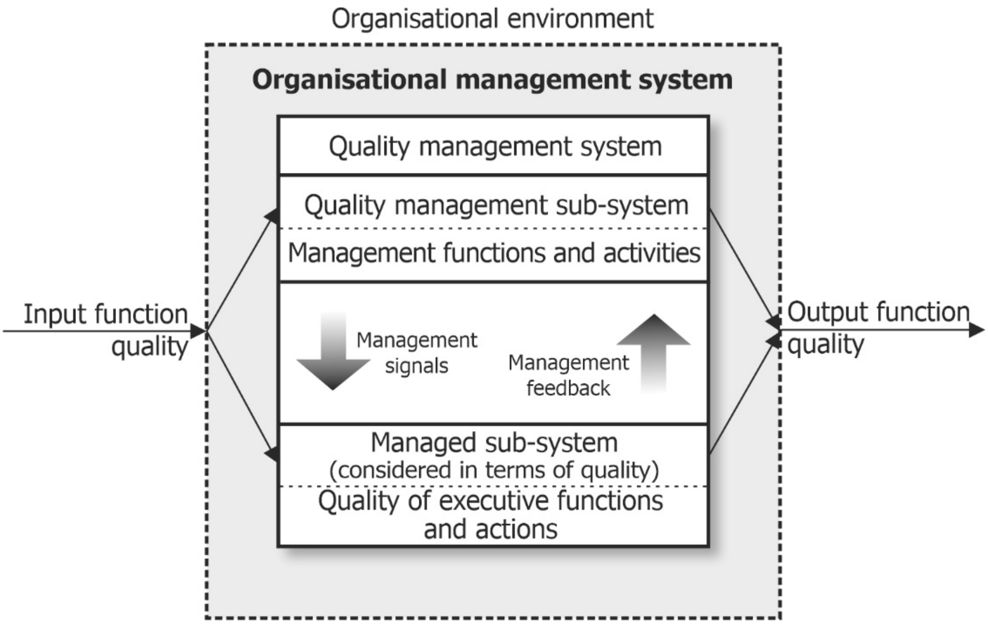

Fig. 4.3. General model of the quality management system

- **environmental influence** on the quality management system, referred to as the input function (IF) and the impact of the system on the environment, referred to as the output function (OF).

The essence of the quality management operation in cybernetic approach, with the application of feedback, comes down to performing management functions with regard to the postulated and actual qualities of the input and output functions and the quality of the managed sub-system. The quality of the input function takes a superior position and is shaped indirectly by the quality management system, using the output function quality. Quality management itself is a complex **information and decision-making process** and consists in adequate gathering and processing of input quality data to management signals to cause postulated qualitative transformations of specific objects.

A material problem related to the quality management operation is the **effectiveness** of achieving qualitative objectives and the **adequacy** of management signals. It is solved within the constrains of objective capabilities which are determined based on: laws of nature (physical, biological etc.), impact of the environment and super-system of quality management, material and non-material resources available as well as the competences of management and executive staff in an organisation. In the set of features of any object which is the object of quality management the **controlled** and **non-controlled features** can be distinguished. Non-controlled features are such features which were excluded from the field of influence of management signals due to their low priority, efficiency barriers or objective non-controllability (non-controlled features). A situation is desired, wherein all features regarded as material were classified as controllable and controlled. The aspect that is fundamental importance for quality management is a **cause and effect** relation in nature [17, p. 106]:

MANAGEMENT SIGNALS (as causes)	$\Rightarrow$	QUALITATIVE CATEGORIES associated to objects (as objectives and qualitative effects)

The cause and effect relation between management signals and qualitative categories may be **determined**, **probabilistic** or **undefined** (uncertain, random). Determined relations demonstrate the highest effectiveness, they are followed by probabilistic relations of high correlation coefficients. The effectiveness of undefined relations is random. In designing the quality management mechanisms (algorithms) one should aim at formalisation of the aforementioned cause and effect relations. In general notation, the formalisation may be presented as quality management function F_z:

$$F_z : \mathbf{Z} \rightarrow \mathbf{K}_j \qquad (4.20)$$

where:
$\mathbf{Z}$ – set of management signals,
$\mathbf{K}_j$ – set of qualitative categories of the quality management object.

The managed sub-system is jointly responsible for the transformation of the quality of the input function ($\mathbf{J}^{if}$) into the output function ($\mathbf{J}^{of}$) which is described using the so-called transformation function (also referred to as the transition function) F_t:

$$F_t : \mathbf{J}^{if} \rightarrow \mathbf{J}^{of}. \qquad (4.21)$$

The above notation of the transformation function, in line with the idea of the so-called black box, does not take into account all significant variables that influence the quality of the output function. In the notation of the transformation function the quality of the managed system ($\mathbf{J}^{zs}$) and the quality of the management signals ($\mathbf{J}^{sz}$) can also be additionally taken into consideration. Therefore, the adjusted transformation function (F_{t1}) assumes the following general form [17, s. 102]:

$$\mathbf{J}^{of} = F_{t1}(\mathbf{J}^{if}, \mathbf{J}^{zs}, \mathbf{J}^{sz}). \qquad (4.22)$$

In the model presented in Figure 4.3 two feedback loops should be stressed. One of them pertains to the quality management processes and occurs in an organisation in the following form [17, p. 102]:

QUALITY MANAGEMENT SUBSYSTEM	→	Management signals	→	MANAGED SUBSYSTEM (qualitative approach)	→	Output quality data OF	→	QUALITY MANAGEMENT SUBSYSTEM

The second feedback loop pertains to external impacts and extends beyond organisation in the following manner [17, p. 102]:

MANAGED SUB-SYSTEM	→	Output quality	→	ORGANISATIONS IN THE ENVIRONMENT	→	Input quality	→	MANAGED SUB-SYSTEM

The presented loops illustrate the relations that occur, on one hand, between the managing and managed sub-systems and, on the other hand – between the organisation and its closer subject-related environment. External feeds that co-create the input function and come from feeding and co-operating organisations are of particular importance for the existence of an organisation. These entities provide organisations with adequate amount of material, energetic, economic and information resources (e.g., raw materials, materials, power, cash, data regarding needs) of proper quality. The environment also emits disturbances which co-create the quality of the input function, a considerable part of which comes from competing organisations and other is random and results from non-controlled or controlled processes.

The quality of environment-based input function of an organisation depends on the quality of its output function, environment-oriented. In the subjective approach to the feedback, a universal **principle of mutual and balanced benefits** is manifested, which, in market-based commodity and money exchange, may be illustrated by the following value flow scheme:

SUPPLIER	→	Product quality	→	CLIENT	→	Cash	→	SUPPLIER

Organisation that takes notice of the significance of the behaviour displayed by entities in its environment (clients, competitors, cooperants, suppliers etc.) uses **marketing orientation** to achieve its goals. Moreover, if the organisation sees the role of quality in influencing these entities, it also uses **pro-quality orientation**. It is worth mentioning that the pro-quality orientation serves the organisation not only in influencing and its external consequences, but equally – in internal influence and its consequences.

The potential scope of quality management overlaps the management of entire organisation. Therefore, the scope covers the quality of all components of three structures in an organisation: **subjective, activities (process)** and **resource**(see [17, p. 127-138]) is presented. The scope identified in this manner shows extraordinary complexity of quality management in organisations included in the system of large organisations. For instance, taking into consideration the impact structure in quality management, the optimum quality of all executive activities of an organisation should be determined and assured. This quality is determined through the quality of a subject, tool, material, purpose and result of each action.

The presented quality management model (Fig. 4.3) is universal and general, therefore it does not take into account aspect such as: the type and size of the organisation, multiple layers and hierarchy of the management system, scheme of organisation's goals, internal structure and types of components of the managing and managed sub-system as well as the complexity of the input and output functions, and complexity of executive and management activities. The need to take into consideration and to detail the above aspects in a situation of developing quality management theory should be regarded as natural.

Reasonable quality management operations require organisational isolation of a **quality management system** within organisational governance. It consists primarily in the creation of a formal organisational structure of quality management system, capable of performing management and executive functions. **Organisational structure** identifies, integrates and organises: organisational units, resources, actions, processes, goals, tasks, results, competences, hierarchies, and responsibility related to quality management.

Quality management operation is a research object in organisational and management science, the achievements of which are worth using in quality management theory and practice. It comes down to, inter alia, classical set of basic management functions (component operations), which include:

- **planning of quality** of artificial objects, including the following operations: forecasting, research, analysis, quality programming and design,
- **quality assurance (organisation)** for all conditions that facilitate reaching the planned quality of objects in executive processes taking into consideration, e.g., The need of stabilisation and uniformity of quality of executive actions and the results thereof,
- **pro-quality leadership** in executive organisational units in executive processes and day-to-day handling of their activities with the aim to achieve the planned qualitative goals,

- **control over qualitative results** of executive processes, which consist in the determination, diagnostics, and comparison with the planned qualitative results, in determination of the size of and reasons for deviations as well as drawing up post-control tasks.

The issue of **complexity** is of primary importance for the applied solutions, development, and classification of quality management operations. The size of the complexity of quality management should be sought both with regard to management and quality. The issue of quality complexity has been solved under the principle of quality approach complexity (see Item 5.4) and the management complexity size are as follows [17, p. 107]:

- scope of management function, considered in schemes of different aggregation level or decomposition of these functions,
- scope of management tools and methods used, taking into account the existing achievements of management sciences,
- scope of executive actions, resources and organisational units of the managed sub-system covered by quality management with regard to all actions, resources, and units in an organisation.

The multitude of dimensions (criteria) of quality management complexity results in the fact that specific dimensions can have different complexity levels. In order to explicitly organise quality management according to complexity level, one needs to formulate a synthetic criterion of complexity. The maximum states of some dimensions cannot be determined in an absolute manner, which makes the classification and organisation of the quality management methods relative in terms of complexity. As a result, it can only be concluded that, according to a specific criterion, certain methods are more complex than others. The method which is characterised by the states of all complexity criteria close to relatively highest states, is referred to as Total Quality Management – TQM.

Chapter V

QUALITATIVE APPROACH IN STUDYING AND SHAPING OBJECTS

5.1. Essence of qualitative approach

The essence of qualitative approach results directly from the research consideration of qualitology and is reflected in the **qualitative perspective of the examination of reality** (Item 2.2). The adoption of feature and quality as the most general and basic epistemological categories results in the fact that the qualitative approach to objects assures a thorough study of their nature as well as forms (representations, images) and manner they employ to be manifested in relations with man. The sense of creating and applying qualitative approach is similar to a well-known and important, from the cognitive perspective, system approach which stems from the science of systems and cybernetics. The basic difference between them consists, however, in the fact that the system approach is characterised by partial and single-aspect study of objects, determined by the notion and features of system, and the qualitative approach – is multi-faceted and complex, determined by the notion of quality[1].

The research perspective of qualitology is expanded in the eleven principles of qualitative approach. When applying these principles, basic qualitative operations are used (Chapter 4). In the broadest interpretation, the

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[1] It is worth noticing that the class of objects referred to as systems was separated based on the common quality assigned to them, referred to as the "system".

qualitative approach covers the **synthesis of all possible aspects** taken into consideration when analysing specific objects in diagnostic, prognostic, design, manufacturing, exploitation, and other activities. Therefore, when making such a synthesis, also system approach, in the form of system principle, was included in the qualitative approach (Item 5.5).

Choice of terminology (Chapter 3), in which quantity was treated as a universal feature co-creating quality, resulted in the fact that also the **quantitative approach** was regarded as a component of the qualitative approach and reflected in the maximisation of the share of quantitative characteristics when applying all principles of qualitative approach. Also, value, as a universal feature co-creating quality, constitutes the **evaluative approach** (axiological) which has also been included in the qualitative approach, and this is reflected primarily in the following principles: anthropocentrism, evaluation, optimisation, and economics.

The identification and application of the qualitative approach in the activities of entities, are grounded in eleven principles developed by the author. A **principle** means a relatively fixed general standard, recommended for use in a certain area of actions aimed at the achievement of specific goals. Principles are often ranked high and are universal in nature, they pertain to methodical or methodological aspects of activities and the application thereof assures, usually, higher effectiveness and efficiency of actions. In further development of qualitology, one needs to factor in the need to develop the methodology of using individual principles of the qualitative approach. The sources of principles and development of methodology of application thereof are usually rooted in both theory and practice.

The general purpose of the application of the qualitative approach is the **improvement of the entirety of human relations with reality** assuring its increasingly broader study and purposeful, effective change. The basic assumption of this approach is that qualitative categories allow the fullest and most accurate representation of any object's nature presented in a descriptive approach, which provides available knowledge of the object; comparative approach – allowing the study of the relation of similarity, diversity and position of a specific object in any scheme with other objects, and axiological approach – allowing a teleological formation of an artificial object and optimum use of a natural object.

The breakdown of the eleven methodological principles which constitute the qualitative approach in the study and formation of objects is presented in Fig. 5.1 [17, p. 41-53].

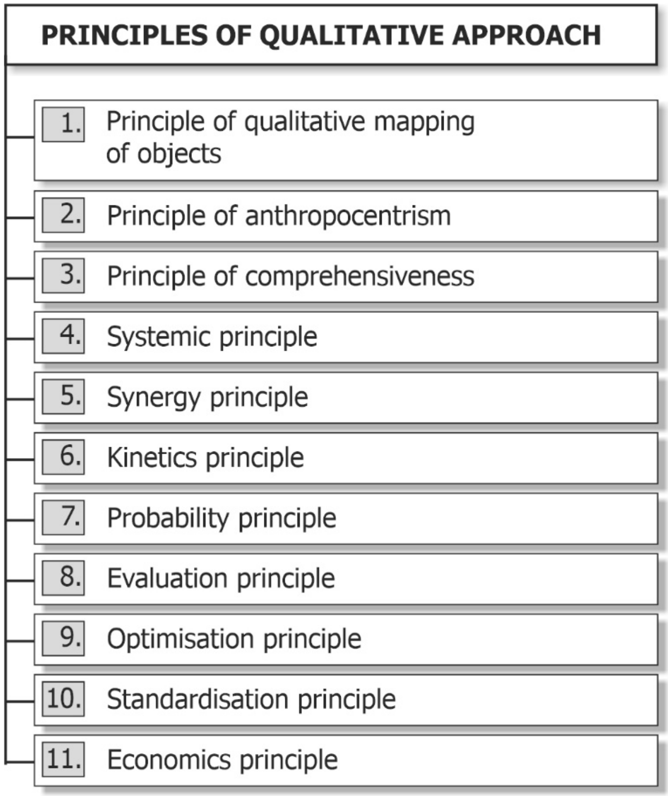

Fig. 5.1. Principles of qualitative approach

The qualitative approach is expressed in each of the eleven principles and in the integrated, comprehensive scheme. Without excluding the possibility of using only selected principles, apart from specific situations, it should be concluded that full **comprehensiveness** of the qualitative approach is externalised in the concurrent application of all principles. It is not difficult to notice the relations between individual principles, e.g., the relation between the principle of anthropocentrism with the principles of evaluation, optimisation, economics, and standardisation. The role of an entity in the application of the qualitative approach results in the fact that axiological aspects occur in each principle, although to a different extent. For instance, they are dominant in the evaluation principle, whereas in the principle of complexity they are not that easy to notice.

The universality of the objective scope, methodological grounds as well as perspective and research objectives of qualitology result in the fact that there is a legitimate possibility to adopt a qualitative approach as a **new paradigm** in scientific research and in practical activities.

5.2. Principle of qualitative mapping

The principle of qualitative mapping in qualitology is a **basic and superior** principle, the essence of which consists in the identification of the considered object using qualitative categories. The general consequence of the application of this principle is the creation of qualitative models (qualitative mapping) of specific objects. A specific and individual result of the application of this principle is the creation of a qualitative and informative model of a specific object using the methodology of qualitative modelling and knowledge resources regarding the object, derived from these scientific disciplines and areas of practices which study the object. In this publication the elements of the theory of quality pertaining to qualitative modelling of objects are created on the grounds of the algebra of sets, proposed definitions of qualitative categories, qualitative operations, and principles of qualitative approach.

The application of the discussed principles to objects when exercising the operations of study, analysis, diagnostics, classification, design, manufacturing, management etc. means that the object should first be regarded in terms of quality, and qualitative mapping of these objects should be used in all operations. The application of the principle of qualitative mapping is closely integrated with the parallel adherence to the remaining principles of qualitative approach.

In the synthetic approach, the sense of the principle of qualitative mapping is determined by the **functions of quality** (app. 3.1), which explicitly assign qualitative categories to objects. The **quality determination operation** (Item 4.1) is of particular importance in the application of this principle.

5.3. Principle of anthropocentrism

The principle of anthropocentrism (humanocentrism) results from the axiological approach to reality, consisting in referring everything man encounters, creates and manufactures to the system of man's needs, values, goals, and requirements. The application of the discussed principle leads, first of all, to the accumulation of knowledge regarding the systems of needs and values of man, which are the source of man's activities, goals, and requirements in conducted activities. The **permanent pursuit of meeting needs** is a universal, primal, and general purpose of the individual and collective activities of entities. In the process of meeting any need, specific detailed goals to be achieved are formulated, and requirements to be met are specified. At the same time, it is necessary to identify the **causal connections** of these goals and requirements with the quality of objects that make up the process of meeting a certain need.

The studies of the systems of needs and values are difficult and complex, and the reasons for that should be sought in extraordinary diversity, size, dynamics, interdependence networks as well as subjectivity of needs and values. In the system of values, a relatively fixed relation of entity's to reality is expressed, and in the system of needs – state of deficits (gaps, shortages, expectations etc.) as well as tensions (discomfort, inconvenience etc.) related to entities.

The division of needs in a number of selected schemes is as follows:

- **primary** needs, regarding people, and **secondary**, regarding organisations,
- **higher-order** needs ranked higher in the hierarchy of needs, and **lower-order needs** which are lower in the hierarchy,
- **individual** needs pertaining to individuals, and **social** needs regarding individual communities,
- **objective** needs, determined using scientific methods, and **subjective** needs determined according to the knowledge and will of entities themselves,
- **aggregated** needs, created using the synthesis method, and **elementary**, created by means of analysis,
- **positive** needs, the satisfaction of which is favourable for a specific entity and/or community, and **negative** needs, the satisfaction of which is to the detriment of the entity and/or community.

The development and comprehensive description of the human system of needs is driven by the application of various interpretations, research perspectives, classifications, and approaches, such as [40, p. 70-71]:

- **biocentric***,* which generate needs taking into consideration survival and individual development (ontogeny), and species development (phylogeny), in natural environment,
- **sociocentric***,* formulating needs in the aspect of social relations in the environment of material and spiritual culture developed,
- **psychocentric***,* which equates needs with subjective feelings, desires, and aspirations of individuals, demonstrated in the spiritual sphere, and formulated based on intellectual, emotional and volitional grounds,

- **econocentric**, considering needs in relation to economic activities in the area of manufacturing, trade and use of goods.

Survival (life) is the most general and superior, and concurrently most natural need of a man, as well as unlimited in time **existence** of species. The development of this need leads to distinguishing primary basic needs. One of the well-known concepts of hierarchy was created by Abraham Maslow, who proposed five levels of needs.

Level 1. **Physiological needs**, the meeting of which is required for individuals to exist. They include: air, food, drink, procreation.

Level 2. **Safety needs**, which must be met to minimise threats and risk in the lives of individuals. They include, *inter alia*, the drive towards protection against destructive or detrimental impact of environment, health security, peace and certainty of events, freedom from fear and destructive stress.

Level 3. **Social needs**, emerging in relation to the operation of individuals in social, professional, environmental, family, political, union or hobby groups. With respect to the relations and social roles that occur, e.g., the needs of belonging, upbringing, education, interpersonal communication, love, freedom, power, care, efficiency of activities, locomotion and cooperation arise.

Level 4. **Esteem needs**, related to the development of relations with social groups and other people that are favourable for individual. They include, e.g., the needs of respect, achievement, acceptance, prestige, distinction, fame, authority, leadership, reward, professional promotion.

Level 5. **Self-actualisation needs**, resulting from the drive of an individual to be fulfilled in every area of spiritual and material life. Self-actualisation may be manifested as self-improvement, creativity, performance of a social mission, sacrifice, altruism, self-education, care of work quality, recreation, or hobby, feeling happiness, joy, pleasure, aesthetic, and ethical fulfilment.

The above basic needs are **primary**, **universal,** and **relatively fixed** in nature and should be generally met in a **universal** and **continuous manner**. The **need for knowledge** may be regarded as particularly important and occurring at all levels in the hierarchy. The presented hierarchy illustrates the urgency and order of meeting needs and changes in the function of progressing satisfaction process – from physiological to self-actualisation needs. The deficit principle is valid at this point – the next unsatisfied need in the hierarchy is the most urgent.

A comprehensive approach to processes of meeting human needs using artificial or natural objects identified qualitatively leads to isolating a category of the **quality of life** (Item 6.4). This category functions as a base reference system in anthropocentric study and shaping of the quality of objects. The synthetic category of the quality of life is also the expression of superior criterion of verification of the purposefulness and effectiveness of any human activities. As R. Kolman claims, the quality of life of a man comprises the quality of family, professional, somatic, habitat, environmental and mental life [28].

Basic primary needs in the processes of decomposition and study of causal connections are developed into series of secondary needs, including also manufacturing in nature, which occur in manufacturing organisations. The satisfaction of needs of any organisations in deliberately created networks of causal connections eventually leads, by assumption, to meeting primary needs of specific people – employees, owners, clients, collaborators etc. Meeting of secondary needs is usually related to the manufacturing, acquisition and use of artificial objects – mainly products designed for production (means of production), and the satisfaction of primary needs – to the consumption or use of consumable goods.

A universal methodological tip in the anthropocentric shaping of quality may be derived from the causal and teleological organisation of primary and secondary needs, as well as corresponding hierarchy of objects, which assumes that the quality of object occurring as **cause** (means, indirect goal) – to quality of a different object, occurring as the **effect** (goal, final objective).

The application of the anthropocentrism principle results in primary tasks, the performance of which consists in:

- qualitative studies of objective and subjective premises and mechanisms of creation, occurrence, and manifestation of needs as well as objects and motivations deriving from them,
- qualitative generation of adequate, full, and hierarchically organised specification of requirements which artificial objects that serve the satisfaction of specific needs must meet,
- shaping the quality of artificial objects that correspond to developed specifications of requirements,
- study of the effectiveness of needs and qualitative adequacy of applied artificial objects,
- counteracting negative influence on the broadly understood quality of social and natural environment due to inadequate quality of objects.

5.4. Principle of complexity

One of the essential features of an object is its complexity (totality) resulting from treating the object as a certain whole, referred to possible variants of the object occurring as larger (more complex) or smaller (less complex) wholes. Therefore, in general, complexity expresses the mutual relationship of variants of a certain whole, demonstrating various ranges thereof. If the notion of a whole is regarded as a feature of an object, then complexity describes the level of that feature.

The notion of complexity (totality) stems from Latin, wherein the term *complexus* means merger into a whole, covering a whole, whereas *totus* means entire, comprehensive. In colloquial meaning and in practice, often only two states of complexity assigned to objects are used:

- complex state (total, complete, full, whole, comprehensive, thorough, exhaustive etc.),
- non-complex state (partial, fragmentary, incomplete, non-full, fractional, non-exhaustive etc.).

The attempt to achieve a higher level of accuracy and detail in the research of complexity requires adequate, analytical formulation of criteria (dimensions, indicators) of complexity as multi-state features.

The complexity criteria are, by assumption, quantitative features, which basically include measurement range, even or quotient scales. A thesis may be put forward that evaluation results in the fact that the complexity criteria are qualified as assets and maximants, as they are characterised by positive states of the feature of value and increasing function of value (Item 3.2). This thesis corresponds to quite common positive assessment of the increase in the complexity of object quality and trends noticeable in scientific research and in practical activities (e.g., TQM demonstrates such trend in quality management).

The principle and notion of complexity in qualitative approach relate to object quality and result directly from rudiments of qualitology, wherein the sets of features were assumed to be unlimited, and only pragmatic considerations usually lead to deliberate limitation of sets of features of objects. This principle gives grounds to a natural drive to maximise knowledge of objects that are under diagnostic, prognostic, design, and other operations, which in turn leads to the increase in the **level of comprehensiveness of object quality**.

The states of quality comprehensiveness criteria for a specific object may be determined if reference points are available, i.e. the highest (s_{kmax}) and the lowest (s_{kmin}) state of a specific criterion or in absence of such points. In the first case the specific comprehensiveness criterion is a feature with range of $\langle s_{kmin}, s_{kmax} \rangle$ and it provides the possibility to determine a unitarised intensity of comprehensiveness in variability range of $\langle 0, 1 \rangle$. This facilities, *inter alia*, the determination of zero and full comprehensiveness. In the latter case, the states of comprehensiveness criterion may be referred only to the adopted base point or mutually to one another, which generates relative states of comprehensiveness. This gives an opportunity to conclude that a specific quality is more or less comprehensive than another.

With regard to these criteria of quality comprehensiveness, the states of which make up even or quotient measurement scale and range of finite length, unitarisation may be applied to determine the intensity of the specific comprehensiveness criterion:

$$p_{ki} = \frac{s_{ki} - s_{kimin}}{s_{kimax} - s_{kimin}} \tag{5.1}$$

where:

p_{ki} – intensity of the ith criterion of comprehensiveness of quality (fits range of $\langle 0, 1 \rangle$),

s_{ki} – state of the ith criterion of comprehensiveness (fits range of $\langle s_{kimin}, s_{kimax} \rangle$),

s_{kimax} – maximum state of the ith criterion of comprehensiveness,

s_{kimax} – minimum state of the ith criterion of comprehensiveness.

If, for a specific quality of an object, the determined state of s_{ki} meets the following equality $s_{ki} = s_{kimax}$, then full comprehensiveness of the quality occurs due to specific criterion ($p_{ki} = 1$), and if $s_{ki} = s_{kimin}$, then we deal with zero comprehensiveness due to criterion ($p_{ki} = 0$). Qualities of objects corresponding to indirect states of a specific criterion of comprehensiveness within the range of $\langle s_{kimaxi}, s_{kimin} \rangle$, generate adequately indirect states of unitarised intensity of quality comprehensiveness, within the range of $\langle 0, 1 \rangle$. As transpires from the above, the fundamental operation in the determination of the level of the comprehensiveness of object's quality is to determine which states of specific criteria of comprehensiveness correspond to this quality.

Due to the possibility of performing arithmetic operations, the application of unitarised form of comprehensiveness criteria allows the creation of a **synthetic quality comprehensiveness indicator** in a situation in which many analytical comprehensiveness criteria are used. Mathematical formulas suggested for the calculation of this indicator include selected forms of mean or the sum of analytical intensities of comprehensiveness criteria of quality.

In general, the comprehensiveness of object quality is determined by two coordinates:

- number of analytical criteria of comprehensiveness taken into consideration, whether or not a maximum number is present,
- set of states of analytical comprehensiveness criteria taken into consideration, with limited or unlimited ranges.

In order to explicitly determine the comprehensiveness of object quality, measures, and methods of measurement of comprehensiveness criteria must be developed. It is suggested that the **cardinality of a set of features** assigned to a specific object and **amount of information** included in this set be assumed as simple and general measures of the comprehensiveness of quality. The higher cardinality of the set of features and/or amount of information, the higher the comprehensiveness of object quality and vice versa.

The analytical study of comprehensiveness of quality consists in taking into consideration at least two partial comprehensiveness criteria. These criteria need to be formulated and adequate measurement scales need to be developed for them, i.e. it is necessary to specify the measures, units of measure and methods to determine their states. Each of the assumed analytical criteria generate usually a different level of comprehensiveness of a specific object's quality. In order to agree on a single synthetic level of the comprehensiveness of object quality, it is necessary to apply a specific method of aggregation of states of analytical comprehensiveness criteria. Similarly, the synthetic level of comprehensiveness may be determined for the quality of objects belonging to a specific set, by adequately aggregating the synthetic levels of comprehensiveness of specific objects' quality.

The application of the comprehensiveness principle requires the specification of quality comprehensiveness criteria and leads to the question of the existence of universal criteria. The analysis of theoretical and practical premises suggested an affirmative answer and led to the development of the following set of universal comprehensiveness criteria for object quality, which include:

- process and time of object's existence (process-based comprehensiveness criterion),
- research perspectives (research-based comprehensiveness criterion),
- entities interested in the object (subjective comprehensiveness criterion),
- objects belonging to the internal and external object structure (structural comprehensiveness criterion).

Process-based comprehensiveness criterion specifies a time horizon for the object's existence – from the moment it appears until it disappears. The level of comprehensiveness of object quality, according to this criterion, is determined by the sum of periods or its share in the entire life cycle of the object, for which qualitative trajectories of the object were established. The full knowledge of the object, i.e. also full comprehensiveness, occurs when the qualitative trajectories over the entire life-cycle are known. Due to the objective conditions and costs of research, qualitative trajectories in the objects' life-cycle are usually established in a discreet manner, taking into account selected dates or period on the time axis.

Research-based comprehensiveness criterion takes into consideration the scope and types of research perspectives which may be applicable to a specific object. As a rule, research considerations correspond to individual scientific disciplines which discover partial qualities of a specific class of objects that are studied (e.g., physical, chemical, technical, marketing, ergonomic, sozological, economic and ethical quality). It is usually difficult to establish a full scope of research perspectives and partial qualities *a priori*. Hence, the comprehensiveness of object quality based on this criterion is relative, which means that only a lower or higher comprehensiveness of a single approach to object quality may be identified, when compared to other approaches. In practice, one notices a trend for continuous increase in the comprehensiveness of research perspectives applied to determine object quality, e.g., as a result of the development of existing and emergence of new scientific disciplines.

Subjective comprehensiveness criterion is defined based on the number and types of subjects (people, organisations, social groups), which, either directly or indirectly, have specific relations with a specific object. These relations usually result in specific and diverse requirements regarding object quality, and they also provide grounds for quality evaluation and verification. Based on the requirements of individual entities, partial qualities of objects may be created respectively, e.g., of product, to suit the requirements of a manufacturer, customer, distributor, legislator. It is difficult to determine the full set of entities interacting with a specific object in its entire life cycle, in particular in reference to indirect relations, regarding further objective environment of the object. Therefore, it is difficult to determine the maximum state of subjective comprehensiveness criterion, which results in the fact that the deliberations in this scope are relative. There is a visible trend for increasing the size of the set of entities taken into account in the processes of researching and shaping object quality. An example of this trend with regard to products in the assumption adopted in TQM, that aside from customers, each employee of an enterprise has an influence on product quality, also there is a need to protect entities in the closer and farther environment against the negative impact of products on natural environment.

Structural comprehensiveness criterion is defined based on the number of objects and relations that make up the internal and external structure of a specific object. A methodological assumption is adopted that **object quality results from the co-existence of its objective internal and external structure** (Items 5.5 and 5.6). Therefore, in the study and shaping of object quality, it is important to analyse the relationship between the object as an isolated whole and objects that make up a multi-level internal structure as well as the relationship between this object – and objects that make up a multi-level external structure (closer and further surrounding of the object). The maximum state of the structural comprehensiveness criterion is expressed by infinity, as according to the omni-relation principle, all reality may be regarded as closer of farther environment of a specific object. Hence, when applying this criterion, pragmatism should be adhered to while determining the size of sets of objects and relations between the external and internal structures as well as the relativism of conclusions regarding the comprehensiveness of quality.

Progress in the application of the comprehensiveness principle in the study and shaping of object quality consists in the proper selection and increase in the number of comprehensiveness criteria and in increasing the states of these criteria. However, despite recognising the importance of comprehensiveness in the study and shaping of object quality, it is difficult to adopt the legitimacy of its maximisation uncritically. Pragmatic premises indicate, that in practice, comprehensiveness of object quality should be applied as optimised category.

5.5. Systemic principle

The application of systemic principle is aimed at the expansion and broadening of the qualitative approach by enriching it with thinking and systemic approach [15, 53, 66]. The grounds for this principle stem from basic qualitative operations (Chapter 4) and other principles of quality-based approach, mainly the principles of synergy and comprehensiveness. Improvement of the created elements of qualitative reality modelling theory based on the set theory, requires supplementing by including a systemic perspective, which is demonstrated mainly by the treatment of object and quality assigned to it as a system[2].

Taking into consideration the diverse definitions and the developed qualitological terminology, the following description of system was assumed (see: [15, pp. 93-94; 53, pp. 106-112]):

Description 5.1. **A system is an object presented as an internal structure connected with external structure.**

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[2] The main stress in the systemic approach "is put on the analysis of **global**, integrating **properties** of the studied object, disclosure of many diverse **feedforwards** and **structure**" [53, p. 14].

Internal structure[3] is made up of a set of internal relations occurring among the components of an object and between components and object as a whole. Object components interpreted systemically are transformed into subsystems. If there is at least one level of complexity, then in a multi-level internal structure systems from the first to nth order will occur.

External structure is made up of a set of external relations between components of an object's environment. Environment covers objects that are not components of a specific object. Closer environment covers objects that have direct relations with a specific object, and farther environment – objects with indirect relations. If objects in the environment are approached systemically and if they include a specific object, then they will be transformed into super-systems from the first to the mth order[4]. Two criteria determine comprehensiveness in identifying the range of environment. First criterion, referred to as the **depth criterion**, is related to the number of levels of indirect relations taken into consideration in the external structure. The second one, called a **spherical criterion**, is characterised by diversity and number of considered external relations and objects in the environment at individual levels of external relations.

All aforementioned elements of the system which is a complex object of specific quality have been organised as the following matrix:

	$p_{zł}$	p_{w1}	p_{w2}	.....	p_{wn}	p_{z1}	p_{z2}	.....	p_{zm}
$p_{zł}$	$\mathbf{R}_{pp}$	$\mathbf{R}_{w1p}$	$\mathbf{R}_{w2p}$	.....	$\mathbf{R}_{wnp}$	$\mathbf{R}_{z1p}$	$\mathbf{R}_{z2p}$	.....	$\mathbf{R}_{zmp}$
p_{w1}	$\mathbf{R}_{pw1}$	$\mathbf{R}_{w1w1}$	$\mathbf{R}_{w2w1}$	.....	$\mathbf{R}_{wnw1}$	$\mathbf{R}_{z1w1}$	$\mathbf{R}_{z2w1}$	.....	$\mathbf{R}_{zmw1}$
p_{w2}	$\mathbf{R}_{pw2}$	$\mathbf{R}_{w1w2}$	$\mathbf{R}_{w2w2}$	.....	$\mathbf{R}_{wnw2}$	$\mathbf{R}_{z1w2}$	$\mathbf{R}_{z2w2}$	.....	$\mathbf{R}_{zmw2}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
p_{wn}	$\mathbf{R}_{pwn}$	$\mathbf{R}_{w1wn}$	$\mathbf{R}_{w2wn}$	.....	$\mathbf{R}_{wnwn}$	$\mathbf{R}_{z1wn}$	$\mathbf{R}_{z2wn}$	.....	$\mathbf{R}_{zmwn}$
p_{z1}	$\mathbf{R}_{pz1}$	$\mathbf{R}_{w1z1}$	$\mathbf{R}_{w2z1}$	.....	$\mathbf{R}_{wnz1}$	$\mathbf{R}_{z1z1}$	$\mathbf{R}_{z2z1}$	.....	$\mathbf{R}_{zmz1}$
p_{z2}	$\mathbf{R}_{pz2}$	$\mathbf{R}_{w1z2}$	$\mathbf{R}_{w2z2}$	.....	$\mathbf{R}_{wnz2}$	$\mathbf{R}_{z1z2}$	$\mathbf{R}_{z2z2}$	.....	$\mathbf{R}_{zmz2}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
p_{zm}	$\mathbf{R}_{pzm}$	$\mathbf{R}_{w1zm}$	$\mathbf{R}_{w2zm}$	....	$\mathbf{R}_{wnzm}$	$\mathbf{R}_{z1zm}$	$\mathbf{R}_{z2zm}$	.....	$\mathbf{R}_{z1zm}$

(5.2)

where:
$p_{zł}$ – complex object of a specific quality,
$\{p_{w1}, p_{w2}, ..., p_{wn}\}$ – set of components of a complex object of specific qualities,

[3] Structure, understood as a scheme of relations between elements of a specific set, covers all types of relations and is one of the aspects of the comprehensiveness of object quality.

[4] In item [53, p. 118] three levels of system descriptions are discussed: the level of external properties of a system, level of system structure and properties of parts of the system and the level of belonging to the super-system.

$\{p_{z1}, p_{z2}, ..., p_{zm}\}$ – set of components of environment of specific qualities,
$\mathbf{R}_{pp}$ – set of relations between qualitative categories (mainly features) of a complex object,
$\{\mathbf{R}_{w1p}, \mathbf{R}_{w2p}, ..., \mathbf{R}_{wnp}, \mathbf{R}_{pw1}, \mathbf{R}_{pw2}, ..., \mathbf{R}_{pwn}\}$ – sets of relations between qualitative categories of objects components and qualitative categories of an object as a whole and vice versa,
$\{\mathbf{R}_{pz1}, \mathbf{R}_{pz2}, ..., \mathbf{R}_{pzm}, \mathbf{R}_{z1p}, \mathbf{R}_{z2p}, ..., \mathbf{R}_{zmp}\}$ – sets of relations between qualitative categories of an object and qualitative categories of components of environment and vice versa,
$\{\mathbf{R}_{w1w1}, \mathbf{R}_{w2w2}, ..., \mathbf{R}_{wnwn}\}$ – sets of relations between qualitative categories of individual object components,
$\{\mathbf{R}_{w2w1}, ..., \mathbf{R}_{w2wn}, \mathbf{R}_{w1w2}, ..., \mathbf{R}_{wnw1}\}$ – sets of relations between qualitative categories of various object components,
$\{\mathbf{R}_{z1z1}, \mathbf{R}_{z2z2}, ..., \mathbf{R}_{zmzm}\}$ – sets of relations between qualitative categories of individual components of object’s environment,
$\{\mathbf{R}_{z1w1}, \mathbf{R}_{z2w1}, ..., \mathbf{R}_{zmwn}, \mathbf{R}_{w1z1}, \mathbf{R}_{w2z1}, ..., \mathbf{R}_{wnzm}\}$ – sets of relations between qualitative categories of object components and qualitative categories of object components and vice versa,
$\{\mathbf{R}_{z2z1}, ..., \mathbf{R}_{z2zm}, \mathbf{R}_{z1z2}, ..., \mathbf{R}_{zmz2}\}$ – sets of relations between qualitative categories of various components of object’s environment.

The term “relation” is treated as original and may be explained using an exemplification method by specifying the set of relation types. The set is made up of, e.g., dependence, similarity, causal connection, function, sequence, belonging, impact, organisation, hierarchisation, sentence form, set of ordered pairs, size, spatial and temporal relations (see: [38, pp. 34-35; 56, pp. 131-166]). Relation occurs between at least two objects (in the set theory they are called arguments [38, p. 35; 56, p. 131]).

The study and analysis of a specific relation gives good **grounds for the formulation of features assigned to objects**, as arguments of these relations. On the other hand, the study and analysis of a specific set of relations may provide grounds for the identification of a relatively complex quality of objects occurring as arguments of this set’s relation. Gradual decomposition of general types of relations, and in consequence also decomposition of features, leads to broadening the knowledge on object quality and make it more specific.

The theory of systems includes: closed-system type, not connected with the environment by relations; open-system type, connected with the environment by various relations; and relatively isolated system type, connected with the environment by relations that are impacts in nature. On one hand, environment impacts the relatively isolated system (input function, set of stimuli), and on the other – the system impacts the environment (output function, set of responses) [38, pp. 35; 40, pp. 234-242][5]. Impacts may be material (energetic, physical, biological etc.) or informative in nature. What is the most adequate in the application of the systemic principle, is that object quality is approached as an open system, taking into consideration various types of relations that make up its internal and external structure.

The adoption of the assumption regarding the omni-relation of objects causes difficulties during the isolation of the object as a system and its environment. The absence of universal and explicit rules of this operation results in considerable freedom and arbitrariness [38, p. 34]. One of the premises underlying the isolation of object as a system may be the occurrence of a larger set of more intensive relations in the internal structure, when compared to the external structure of the object. The number, type and intensity of internal relations determines the so-called **system coherence**. An essential qualitological premise regarding system isolation is the occurrence of a qualitative result of synergy, including the proper result of synergy as a criterion for isolation and qualification of objects to various classes: complex objects, systems, and wholes (Item 5.6). Concurrently, a thesis may be formulated, that freedom in determining system boundaries and environments supports volitional and creative control of the processes of researching and shaping reality.

The notion of system in the theory of quality may be understood not only as a specific or general name of a given object or a certain class of objects, but also as partial quality assigned to specific objects. Such objects may be referred to as having **systemic features**, and collectively – systemic quality. If the notion of system is referred to an object, then, in compliance with the qualitological principle of equating object with its quality, this notion is at the same time referred to the quality of this object (matrix 5.2). This means that **object quality may be interpreted and identified as a system**, determined, and defined by the quality of object components that make up its internal structure, considered in relation to the external structure, composed of the environment components' quality.

In this approach, arguments of relations which make these structures up, are qualitative categories assigned to a given object and its components, as well as to objects of environment. Among these categories, the category of feature holds a central place, and the elementary object of systemic research covers relations between features, in particular relations demonstrating functional dependences and causal connections. The discovered relations that

[5] A specific case of a relatively isolated system is a control system comprising a controlling and controlled subsystem connected by feedforward or feedback.

are universal and permanent regularities are of particular value. What is particularly important in diagnostic and design research, are the relations between object features and the features of its components (a known, typical relation: part *R* whole). As a result of the study of relations between features, new features of a given object, its components or objects in the environment may be created.

As results from the application of a system approach, the quality of object (system, subsystem, super-system) is conditioned by, concurrently, the quality of object components and internal structure as well as the quality of environment components and external structure[6], which may be generally and symbolically presented as:

$$\mathbf{J}^{p} = f_{p}\,(\mathbf{J}^{\mathbf{W}}, \mathbf{R}_{wew}, \mathbf{J}^{\mathbf{Z}}, \mathbf{R}_{zew}) \qquad (5.3)$$

where:

$\mathbf{J}^{p}$ – object quality,

$\mathbf{J}^{\mathbf{W}}$, $\mathbf{J}^{\mathbf{Z}}$ – respectively, set of qualities of object components and set of qualities of object's environment components,

$\mathbf{R}_{wew}$, $\mathbf{R}_{zew}$ – respectively, set of internal relations and set of external relations.

Therefore, object quality is conditioned **bilaterally** and occurs somewhat at the "contact surface" of the aforesaid components and structures. It may be symbolically assumed that this contact surface is made up of object and environment components, between which direct relations occur. Object quality and its systemic conditions may be determined statically – in a specific period of object's lifecycle or kinetically – in the process of change in object and external conditions. From the quality engineering perspective, a significant conclusion can be drawn based on the system approach to quality, that the shaping of quality of a complex artificial object consists in the shaping of independent variables in dependence (5.3).

The developed methodological elements of the principle of system-based approach to quality of objects are adequate to the needs of both cognitive and manufacturing human activity. They enable more comprehensive, cognitively deeper, and practically more effective handling of object quality.

5.6. Synergy principle

The application of the synergy principle consists in consideration of the phenomenon of synergy when studying and shaping object quality. This

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[6]A.D.Hall concludes that "in principle, environment determines all system properties" [15, p. 22].

phenomenon has not been fully explained to date, despite the fact that it is the subject of interest of many scientific disciplines, such as: chemistry, physics, pharmacology, sociology, praxeology, ecology, organisation, and management sciences. The word "synergy" comes from Greek *senergos* meaning: collaborative, and, in a broader sense – cooperative. Tadeusz Kotarbiński concludes that synergy occurs when cooperating entities gain more that those operating separately, and Tadeusz Pszczołowski understands synergy as such a combination of at least two elements so that their interaction yields higher results that the sum of results gained by each elements separately [17, p. 49]. Such understanding of synergy corresponds, in particular, to the systems of operation, including organisations which are oriented on achieving and maximising synergy effects.

The above interpretations show significant limitations in the comprehension of synergy, resulting from the semantic scope of employed terms: "collaboration", "co-operation", and "interaction"; and from the adopted assumption regarding the aggregation of results and condition of specific inequality of results. The consequence of these limitations is that the theory based on such an understanding of synergy will not be adequate to synergy phenomena occurring in other areas of reality which do not belong to systems of operation. This inspired the attempt to justify the thesis regarding the possibility of universal explanation of the phenomenon of synergy on the grounds of qualitology [40, pp. 61-66].

As has been demonstrated, the elementary focus of research in qualitology is the object, treated as a separate component of reality, with a specific internal and external structure. Separating an object from reality and assigning features of whole and system to it inevitably leads to the phenomenon of synergy, as the category of whole occurs inseparably from its internal and external structure which constitutes the "contact surface" of these structures [38, pp. 33-39].

In qualitative approach, the phenomenon of synergy is demonstrated in the **dissimilarity** of a specific complex object considered on the grounds of external structure, in relation to the components of its internal structure. The phenomenon of synergy results in the fact that object quality does not result, *explicite*, from the quality of components of internal and external structure. This may be reflected in those definitions of system, in which system is understood as elements connected with one another by relations and making up a whole which is **different** from the sum of elements [53, pp. 26-27].

The consideration of fundamental circumstances of the **consequence of synergy in qualitative approach** leads to the creation of a synergistic system expressed as a generally formulated relation of three arguments:

$$\left\{\begin{array}{c}\text{Qualities of}\\ \text{complex ob-}\\ \text{ject's compo-}\\ \text{nents which}\\ \text{make up the in-}\\ \text{ternal structure}\end{array}\right\} \begin{array}{c}\textbf{Synergy}\\ \Leftrightarrow\\ \text{(set of in-}\\ \text{ternal re-}\\ \text{lations}\\ \mathbf{R}_{int})\end{array} \left\{\begin{array}{c}\text{Quality}\\ \text{of com-}\\ \text{plex ob-}\\ \text{ject}\\ -\textbf{result}\\ \textbf{of syn-}\\ \textbf{ergy}\end{array}\right\} \begin{array}{c}\text{Set of}\\ \Leftrightarrow\\ \text{exter-}\\ \text{nal re-}\\ \text{lations}\\ \mathbf{R}_{ext}\end{array} \left\{\begin{array}{c}\text{Qualities}\\ \text{of ob-}\\ \text{jects}\\ \text{which}\\ \text{comprise}\\ \text{external}\\ \text{structure}\end{array}\right\} \quad (5.4)$$

The above relation leads to the following, proposed description of synergy on the grounds of qualitology:

Description 5.2 - **Synergy is the set of internal relations in the set of objects, which results in the fact that together they comprise a complex object of quality different from the sum of qualities of these objects, taking into consideration the set of external relations.**

Based on description 5.2, the factor determining the occurrence of synergy is the dissimilarity of the quality of a complex object isolated from the sum of qualities of objects comprising that object, taking into consideration the set of relations with objects in the environment. At this point it is assumed that the quality of a complex object will be referred to as a **qualitative synergy result**[7]. Studies of synergy may be conducted using various qualitative categories, however, the most representative categories include the categories of a set of features and states of features assigned to objects. The definition of a condition for synergy specified with the use of these categories is presented in the dependences below:

$$\mathbf{J}^1 \cup \mathbf{J}^2 \cup \mathbf{J}^3 \cup .... \cup \mathbf{J}^n \neq \mathbf{J}^p \text{ and } \mathbf{J}_s^1 \cup \mathbf{J}_s^2 \cup \mathbf{J}_s^3 \cup .... \cup \mathbf{J}_s^n \neq \mathbf{J}_s^p \quad (5.5)$$

where:
$\mathbf{J}^1$, $\mathbf{J}^2$, $\mathbf{J}^3$, ..., $\mathbf{J}^n$ and $\mathbf{J}_s^1$, $\mathbf{J}_s^2$, $\mathbf{J}_s^3$, ..., $\mathbf{J}_s^n$ – respectively, sets of features and set of states of features of objects that are components of a complex object, in the n number,
$\mathbf{J}^p$, $\mathbf{J}_s^p$ – respectively, set of features and set of states of features of a complex object.

The occurrence of the qualitative synergy effect means that a specific set of objects is transformed into a complex object with features of a **whole** and **system**. In accordance with Aristotle, who claimed that a whole is more that

[7] When developing the principle of synergy, the term "synergy result" instead of "synergy effect". This is an important change and a consequence of assuming an extended interpretation of synergy and deviation from defining this notion only in the aspect of a larger and more positively judged result, which was referred to as synergy effect.

a sum of parts, the qualitological definition of synergy suggests that the quality of the whole is not equal to the sum of the quality of parts. The basic types of relations determining the synergy effect include: causal connection, feedforward, function, co-existence, relation, interaction, activity, co-operation, action, reaction, similarity, position in space in time. The **relation of co-existence** of component objects is a particular one, it conditions the existence of a complex object and the occurrence of other relations.

The partial quality, which directly determines the dissimilarity of this object's quality from the quality of its components is particularly significant in the study and shaping of the synergy effect in the form of the quality of a complex object. It is created only by these features, states of features or other qualitative categories of a complex object, which do not belong, simultaneously, to component objects. It is proposed that the partial quality isolated in that manner be referred to as the **qualitative proper synergy effect**. The dependences describing the proper synergy effect for features and states of features of complex objects are as follows:

$$\mathbf{J}^p - (\mathbf{J}^1 \cup \mathbf{J}^2 \cup \mathbf{J}^3 \cup .... \cup \mathbf{J}^n) = \mathbf{J}_{pr}{}^p \neq \emptyset,\ \mathbf{J}_{pr}{}^p \subset \mathbf{J}^p \text{ and}$$

$$\mathbf{J}_s{}^p - (\mathbf{J}_{s1} \cup \mathbf{J}_{s2} \cup \mathbf{J}_{s3} \cup .... \cup \mathbf{J}_{sn}) = \mathbf{J}_{swł}{}^p \neq \emptyset,\ \mathbf{J}_{swł}{}^p \subset \mathbf{J}_s{}^p \qquad (5.6)$$

where:

$\mathbf{J}_{wł}{}^p$ and $\mathbf{J}_{swł}{}^p$ – respectively, qualitative proper synergy effect expressed by the set of features and set of states of features.

The dependences (5.6) take into consideration the assumption of occurrence of the qualitative proper synergy effect only if it is a set composed of at least one element. The proper synergy effect, as partial quality, is included also in categories $\mathbf{J}^p$ and $\mathbf{J}_s{}^p$ of a complex object. The detailed and specific description of synergy is based on thorough study of real mechanisms and patterns in the occurrence of effect and proper effect of synergy of a specific complex object.

The essence of synergy is expressed by a set of relations $\mathbf{R}_{wew}$ occurring between qualities of components and the quality of a complex object, taking into consideration the set of relations $\mathbf{R}_{zew}$ between quality of objects belonging to the environment and quality of a specific complex object (dep. 5.4). The explanation of synergy consists in the study of the above mentioned relations and identification of dependences between properly isolated elements of the qualitative internal structure and the individual elements of synergy effect, including the proper synergy effect. In the discovered and formalised dependences, the qualitative categories of component objects and objects in the environment have the function of independent variables and qualitative categories of a complex object – dependent variables. The basic condition for correctness of formulated dependences is the adequate, true, objective, and exhaustive representation of real phenomena. Dependences explaining the common and fixed patterns occurring in reality are particularly valuable (e.g., synergy effect of a chemical reaction of oxygen with hydrogen, which occurs as quality of water). Learning such patterns is condition precedent for forecasting and designing qualitative synergy effects.

The elementary approach to synergy considered in the scheme of features consists in the occurrence of such an ensemble of features of specific component objects, which comprises a given feature, belonging to the synergy effect of the complex object. On the other hand, the elementary approach to synergy considered in the scheme of states of features consists in the occurrence of such an ensemble of states of features demonstrated by specific component objects, which comprises a given state of feature, belonging to the synergy effect of the complex object. It is worth noting that in qualitative interpretation, synergy occurs also when the state of feature of a complex object is equal to the sum of states of this feature that are assigned to specific component objects. The synergy effect in the form of the sum of states of feature is typical only of quantitative features with absolute or uniform measurement scales.

The proposed concept of qualitative interpretation of synergy gives opportunities to determine the **size of synergy effect**. This size may be, for example, determined by cardinality of sets: $\mathbf{J}^{p}$, $\mathbf{J}_{s}^{p}$, $\mathbf{J}_{wł}^{p}$ and $\mathbf{J}_{swł}^{p}$. The determination of the size of synergy effect makes it possible to assign a feature of whole and system to an object and to qualify an object to the following classes: complex objects, whole or system. If the size of synergy effect is zero, then the given object does not belong to any of the above classes[8]. As the size of synergy effect may also be above zero and rising, then the qualification of objects to the above mentioned classes on that basis is **fuzzy**. The size of the synergy effect occurs in this case as a function of belonging, creating fuzzy sets of complex objects, wholes, or systems. As a result, it is concluded that a given object does or does not belong, to a specific extent, to these sets.

In the to-date deliberations, both synergy and the consequences thereof were regarded as neutral and did not take into consideration the evaluating approach. The **axiological assessment** of its qualitative consequences is a separate issue in the complex study of synergy. The methodological bases for evaluation and optimisation of synergy effects are analogous as in the case of evaluation and optimisation of object quality (Items 4.4 and 4.5).

[8] What remains to be considered, is the effect of synergy that characterises the objects referred to as set. A thesis may be formulated that the size of synergy effect of a set is equal to zero.

This stem, obviously, from the fact that synergy effects are expressed in qualitative categories. The result of evaluation is, *inter alia*, the division of qualitative synergy effects into:

- **positive** (values, effects),
- **negative** (shortcomings, losses),
- **neutral** (regardless of the specific evaluation criterion).

The research of synergy and its consequences is handled in the scheme of analytical and synthetic, cognitive and design activities. Analysis and synthesis occur always when the entity considers or creates reality in a multi-level complexity structure. An example of the use of the synergistic scheme is the process of designing the quality of complex products, wherein one of the tasks consists in the search for the optimum internal qualitative structure of product based on:

- postulated quality of the designed product with view of needs, goals, and specification of requirements,
- postulated qualities of components occurring at all levels of product complexity,
- discovered dependences between product quality and the quality of its components,
- discovered dependences between qualities of components on the sale or various levels of product complexity,
- discovered dependences between product quality and the quality of objects in its environment.

The standard problem with formulation consists in determining the quality of components which, in the postulated synergistic scheme, will assure that optimum product quality will be achieved as a synergy effect. The effectiveness of formulation depends primarily on achievements in the discovery or study of objective synergy mechanisms.

5.7. Kinetics principle

The kinetics principle takes into consideration the objective and common **phenomenon of object quality variability in the time function**. The kinetic approach is equal to the **process** approach and consists in determining the trajectory of qualitative changes that objects undergo over the entire life cycle, caused generally by a complicated combination of reasons. These trajectories run in a multi-dimensional space of the set of features and the possible states thereof. The quality change processes consist of two types of events:

- based on the appearance or disappearance of certain features,

- based on the transformation of some states of features into other states.

The first type of events comprises quality change processes on the level of set of features, and the second one – quality change processes on the level of sets of states of features. These processes are typical of the first and second degree of accuracy of the study of object quality. The results of observation justify the thesis that changes to objects' quality are characterised by relatively lower intensity than changes in state of quality. Qualitative changes are conditioned causally and have their own **rate** and **dynamics**. The rate of quantitative, differentiable changes may be determined by the first differential with respect to time. In general, the rate of qualitative changes may be determined by the frequency of occurrence of first and second type events in the unit of time:

$$T_C = \frac{L_C}{t_x} \; i \; T_S = \frac{L_S}{t_x} \tag{5.7}$$

where:

T_c, T_s – respectively, frequency of the occurrence of the first and second type events,

L_c, L_s – respectively, the number of first and second type events which occurred in time range t_x.

The dynamics of qualitative changes characterises causal connections in which specific causes result in specific qualitative changes. The dynamics of qualitative changes of quantitative, differentiable changes may be determined by the second and consecutive differentials with respect to specific causes. The knowledge of dynamics of changes makes forecasting of qualitative changes easier and more accurate, and more prone to control.

Examples of elementary types of changes in states of quantitative and linguistic features are presented in Fig. 5.2.

The kinetics of qualitative changes is best represented by the chronological sequence of the states of quality of the studied object, taking into account also the changes in the set of features that occur in parallel. The process of identifying states of quality as a function taking into consideration any point on the time axis reflects the idealised model situation. On the other hand, in practice, it is usually not possible, and frequently also not necessary, to continuously record states of object quality in the so-called real time. There may, however, be situations, wherein the states of selected features are continuously measured[9].

[9] For instance, such situations occur in meteorology, when selected atmospheric variables are measured continuously, and in medicine, when selected physiological variables are measured continuously.

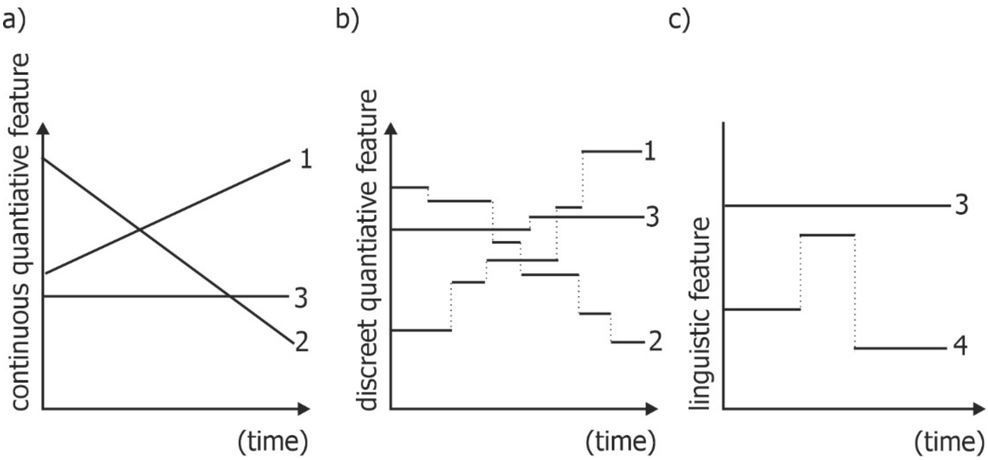

Fig. 5.2. Examples of change variability types [39, p. 84] (description in text)

Objective conditions and pragmatic reasons justify the application of discreet (discontinuous) trajectories of quality and conventional approach to specific sections on the time axis as time limits for determining states of object quality. The same reasons determine also the schedule of research and postulated number of the states of object quality identified in the assumed time period. A premise factored in while determining these parameters includes isolatable phases of the change process the studied object undergoes. These phases may be, for example, distinguished due to stability of the state of quality. Taking into account this trait, the states of object quality should be determined on a one-off basis for individual phases of considerable level of stability and with adequate frequency – for phases with considerable rate of changes.

Due to the deliberate participation of man in the process of qualitative changes, the changes may be divided into:

- **natural**, resulting from natural causes and laws (physical, meteorological, chemical, astronomic, biological etc.),
- **artificial**, resulting from human activity, conducted with consideration of natural causes and law.

Artificial changes are, by assumption, deliberate, subject to evaluation and optimisation. In the set of deliberate changes, also negative qualitative changes may occur, by way of condition precedent. The operations of evaluation and optimisation of artificial qualitative changes and evaluation of qualitative changes consist in the comparison of the results of these operations, referred to states occurring **before** and **after the change**. The qualitative change itself is assessed as positive, if the post-change status was graded relatively higher.

Artificial qualitative changes are inseparably related to the lifecycles of artificial objects, including products. The trajectory of changes and time limits for determining product quality are related to its three-stage life cycle. In the preparation stage, a moment in which the design quality of product is determined may be distinguished. In the manufacturing stage, a sequence of qualitative transformations of materials occurs in technological processes until actual quality and manufacturing quality of specimens of final product are achieved. The operating stage is dominated by a sequence of qualitative transformations caused by the use and operation of product's specimens. The entire cycle is completed by the quality of product specimens qualified for liquidation. Due to qualitative heterogeneity of the manufacturing and operating stages, a phenomenon of heterogeneity and individualisation of quality trajectory in the set of product specimens occurs.

5.8. Probability principle

The probability principle is universal and common, as it pertains to objective and common **randomness phenomenon** of categories and qualitative changes of objects. The application thereof consists in a comprehensive use of probability calculus and mathematical statistics methods in the study and shaping of object quality [29]. One of the principal notions of the above mentioned scientific disciplines is probability, referred to events and random variables. This notion is connected with the problem of heterogeneity and uncertainty in determination of qualitative relations and random events. It is assumed that the elementary qualitative random event is the belonging or non-belonging of a specific qualitative category, in particular a feature or a state of feature, to a given object.

Statistical surveys determine, *inter alia*, distributions of probability of random variables, measures of central tendency and dispersion, estimators of parameters, veracity of hypotheses, regression functions and correlation coefficients. The basic assumption underlying the discussed principle is the reasonable treatment of specific qualitative categories, mostly features, as random variables[10].

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[10] Probability calculus and mathematical statistics form part of general education are extensively discussed in literature and therefore will not be presented at this point.

In the research of object quality, conducted in the diagnostic, prognostic or postulative aspects, three types of features may be distinguished due to the phenomenon of randomness (see Fig. 3.1):

- **deterministic***,* characterised by explicitness and certainty that these features and the states thereof will occur in respect of objects in a given set,
- **random, of known distributions***,* for which distributions and values of probability, that these features and the states thereof will occur in respect of objects in a given set, are known,
- **random, uncertain***,* with absence of certainty and knowledge regarding the probability of the occurrence of these features and their states with respect to objects in a given set.

What is very interesting, in the cognitive aspect, is the issue of interpreting the state of quality on the grounds of probability, using the **probability function** (μ_p) of set $\mathbf{J_s}$, which takes on values from the range of $\langle 0, 1\rangle$[11]. This function is used to determine the value of probability of the occurrence of individual states of features (s_c) from set $\mathbf{J}_s$. In general, the deterministic and random state of quality ($\mathbf{J}_{sdl}$) is a set of organised pairs:

$$\mathbf{J}_{sdl} = \{(s_c, \mu_p(s_c)) \mid s_c \in \mathbf{J}_s\}, \text{ whereas } \mu_p\colon \mathbf{J}_s \to [0, 1]. \quad (5.8)$$

In set $\mathbf{J}_{sdl}$ one can distinguish a **deterministic subset** of states of features for which $\mu_p(s_c) = 1$, and a **random subset** of states of features for which $0 \leq \mu_p(s_c) < 1$.

The application of the probability principle is increasingly common. It is recommended to use statistical methods in quality control, process control, and, in most general terms, in quality management [17, pp. 208-303]. Starting with Walter Andrew Shewhart, most classics of qualitology appreciated and recommended the use of statistical methods.

What seems interesting, is the signalling of practical quality-related problems occurring over the lifecycle of an artificial object (product), the solving of which requires that the probability principle be taken into consideration. At the beginning of the cycle, statistical survey must be conducted to determine the qualitative needs, requirements, and preferences of the population of entities that are potentially interested in the conceived artificial object[12]. The identified distributions of statistical characteristics of qualitative needs,

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[11] Similarly, as in the case of membership function in the fuzzy sets theory. In consequence, a new category of a **probable set** (**deterministic and random**) emerges.

[12] In economic activity conducted adequately to market situation, they mainly include surveys aimed at determining the complex of marketing requirements in particular requirements of selected segments of end customers, future users of the product.

requirements and preferences enable, *inter alia*, the segmentation and adequate differentiation of design quality of an artificial object.

Other statistical surveys and information necessary to determine design quality of an artificial object pertain to broadly understood conditions and environment of the operating stage (use and operation processes, social and natural environment, infrastructure, legal system etc.) and the entirety of manufacturing conditions (technique, technology, structural materials, infrastructure, organisation, resources, qualifications etc.). The statistical research of the manufacturing stage enables, e.g., the determination of **qualitative homogeneity** and manufacturing quality of artificial object's specimens. One of the reasons for randomness of features of manufactured specimens is the randomness of features of structural materials and features of components on all levels of artificial object's complexity.

The randomness of features in the shaping of artificial objects' quality is only partially a controllable phenomenon, it is largely a function of non-controllable and/or non-controlled factors. Despite that fact, entities participating in the life-cycle of these objects aim at reasonable reduction of the randomness of features and improvement of parameters of statistical characteristics. In this respect, opportunities grow along with the development of scientific research and measurement, manufacturing, and operating techniques. Therefore, a designer determines the basic postulated characteristics of the distribution of random features, taking into account mainly the statistical characteristics of manufacturing and operating stages of an artificial object. The statistical characteristics of random features are related to tolerances established for these features, which determine the postulated qualitative homogeneity of artificial object's specimens.

Examples of design tasks, probabilistic in nature:

- determination of reliability, which, by definition, is the probability of failure-free operation of an object in specific conditions and over assumed time limit,
- determination of tolerance in fits and chains of dimensions as well as assurance of replaceability of components of a material artificial object,
- determination of qualitative capacity of manufacturing basis' components[13],

[13] Qualitative capacity determines qualitative adequacy of a specific component of the manufacturing base (e.g., process machine, material, worker) to the postulated quality of the manufactured artificial object or the components thereof [17, pp. 297-300]. The higher the qualitative capacity, the higher the probability that a specific component of manufacturing base will assure the postulated quality of a specific object or a component thereof (and vice versa).

- development of technological processes, including the selection of machines, tools and instruments based on their qualitative capacity and assumed parameters of the distribution of random features of manufactured artificial object specimens and components thereof.

Economic aspect is related to the application of the probability principle, which is connected, *inter alia*, with the costs of statistical surveys, costs of incompatibility, manufacturing costs and economic optimisation of manufacturing quality of artificial objects (Item 5.12). In business activity, the statistical methods of quality control are widely applied, including the statistical methods of process control and quality acceptance [17, pp. 267-297].

5.9. Evaluation principle

The evaluation principle reflects the common and significant need to transform non-evaluated quality of objects into evaluated quality. The need occurs always in the processes of assessment and decision-making regarding object quality[14]. The analysis of achievements of qualitology leads to a conclusion that one of the primary research issues is the development of the methodology to evaluate the quality of objects, also referred to as quantitative determination, relativisation or hierarchisation of quality [38, p. 72]. The importance of this issue results from the needs and expectations of socio-economic practice, related primarily to quality management. The multi-faceted and complex nature of quality, antinomies of features, natural relativism of the notion of value and very diverse operation are the reasons for considerable diversity of methodological solutions in the area of quality evaluation [38, p. 73]. Attempts to develop an objective synthetic quality indicator, considered in terms of value, which differ mostly in the set of analytical features of value and mathematical formula of their aggregation [27, 29].

The fundamental difficulty in the application of the evaluation principle results from the fact that in social sciences the notion of value belongs to the most ambiguous ones [38, p. 74]. It is semantically vague and demonstrates multi-lateral relativism and considerable variability, has a numerous set of various designata and factors and is particularly sensitive to subjective interpretations. This situation, *inter alia*, causes that three directions of research must be taken into consideration in the application of the evaluation principle:

[14] The substantive overview of the evaluation operation is presented in subchapter 4.4, therefore some additional issues will be mentioned at this point.

- observation, analysis, and discovery of individual and statistical regularities occurring in the **social practice of evaluating the quality** of objects,
- **objectivisation of the quality evaluation processes** through the development of scientific grounds and methodology of object quality evaluation,
- analysis and determination of **variance** in the social and objectivised evaluation of object quality.

The diversity and mass nature of social practice in the area of qualitative decision provide a vast empirical material for the first direction of research. There are usually unprofessional decisions pertaining to private life, including broadly understood consumption and consumer products, as well as market behaviour. The results of observations show that qualitative decisions in social practice are most frequently made upon superficial, fragmentary, and uncertain recognition of decision-making situation. Often absence of sufficient knowledge of the quality of studied objects occurs, as well as absence of explicit and organised structure of individual needs. The quality evaluation process itself is usually **subjective** and **intuitive** and occurs with the participation of emotional and volitional factors, often accidental and irrational. Another important feature of social evaluation of quality is high rate of changes in the factors of this process and poor traceability of causal connections in decision-making processes. The highlighted circumstances result in the fact that the quality evaluation processes and results are **random**, **variable,** and **individualised** which is equal to their diversity in time and social space.

The conditions for social evaluation of quality result in the fact that the individual results may be treated as random events, the study and description of which requires appropriate probabilistic and statistical methods. Major results of such research include the discovered statistical characteristics and regularities (dependences). It is difficult to overestimate the importance of the study of social practice of quality evaluation in optimised shaping of artificial objects quality in manufacturing organisations, as, regardless of any drawbacks of this practice, it remains reality which should be known and taken into consideration.

Based on the to-date deliberations, it may be concluded that if an object is subject to the practice of social evaluation, then many evaluated qualities will be generated based on its non-evaluated quality, which is illustrated in Figure 5.3. Upon meeting the condition of sufficient size of sets of features of values assumed by entities in the process of social evaluation, there will be as many evaluated qualities of the specific object as there are evaluating subjects. It is suggested to refer to this phenomenon as the **differentiation of evaluated quality** of objects.

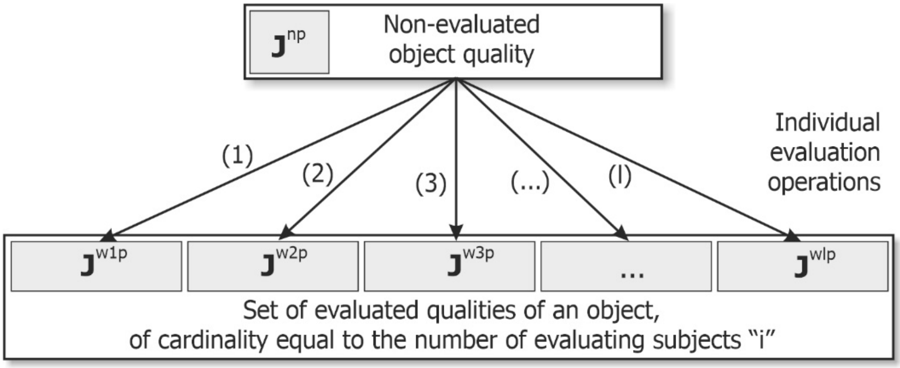

Fig. 5.3. Differentiation of evaluated object quality

The relations between the practice of social evaluation of quality with systems of preference and motivation of people can be seen. These relations may be studied individually or statistically. Proper analysis of results of quality evaluation leads to the determination of value-based hierarchy of preferences and motives, which concurrently represents the **qualitative preferences**, individual or collective. A universal motivational factor in social evaluation of quality is the need to make the best qualitative decisions possible. On the other hand, evaluations motivate for proper actions and execution of qualitative decisions made. The knowledge of the results of the social evaluation of quality, preferences and motivations is indispensable for manufacturing entities supplying and supporting specific persons or social groups[15].

The second of the aforementioned directions of research, related to the evaluation principle, takes into consideration the need to **objectivise** and **professionalise** the quality evaluation processes. This need occurs in organisations which employ these processes in their activities, taking into account, for instance, social interest. The objective of this direction of research is to create theoretical grounds and methodology of quality evaluation. As part of quality theory, methodological grounds for objectivised evaluation of quality are developed, and, under quality engineering – methodology useful for that purpose [28]. This methodology is used and verified mainly by organisations shaping the quality of artificial objects.

The developed methodology should assure the possibility to eliminate drawbacks occurring in common practice of social evaluation of quality. This

[15] For instance, marketing operation of market segmentation using similarity of consumers due to preferences, motives and behaviours in shopping processes is used for the isolation of such persons and groups [41, pp. 67-71].

may be achieved by exhaustive and objective determination of the non-evaluated quality of object and need it is supposed to satisfy and, resulting from this need, specification of requirements, and then through rational selection of criteria and functions of value, as well as formalisation of the evaluation process. The objectivised evaluation of object quality may also generate a series of evaluated qualities, if the reasonable multi-variant situation of evaluation is taken into consideration, which determines, *inter alia*, the diversity of segments of users, needs, requirements, criteria, and functions of value. Therefore, adopting the assumption regarding the occurrence of just one result of objectivised evaluation of object quality is unfounded. A single result of such evaluation may occur only in situation of complete homogeneity of an object's users.

From the comparison of characteristics of both quality evaluation methods results a hypothesis that the degree of differentiation of evaluated quality of objects is relatively higher in the case of social evaluation than in the case of objectivised evaluation.

The third direction of research covers problems emerging in relation to the parallel occurrence of the practices of social and objectivised evaluation of object quality. The thesis regarding the occurrence of **discrepancies** between the results of these methods of evaluation is grounded. The reason for discrepancies is the difference of assumptions, objectives, and methods of evaluation. The assumption underlying social evaluation is the right of entities to individualised approaches and subjective interpretations, and in professional evaluation average (general) approaches and objective recognition of situation is employed.

There are two types of discrepancies between the results of quality evaluation. The first results from the differences between separate individual results and objectivised results (individual differences) and the other – between adequately averaged individual results and objectivised results (averaged difference). The first type of discrepancy is, by assumption, a natural phenomenon and the other type demonstrates a conflict between social and objectivised evaluation and causes some consequences in relations between the entities on both sides, i.e. between consumers and manufacturers of practical goods. The occurrence of such conflict means that the given population of consumers does not accept the specific quality of object offered by a specific supplier.

The premises indicated above allow the formulation of a conclusion of a **bidirectional** nature of the works on methods of objectivised evaluation of quality. The first direction pertains to methods which, by assumption, are supposed to assure the fullest possible consistency of social and objectivised evaluation results. Therefore, their structure must adequately factor in the results of statistical surveys of social evaluation of quality. The other direction pertains to methods which, by assumption, are not based on social evaluation of quality but on scientific objectivised approach. The application of this method by suppliers causes a need to convince consumers to change their method of evaluation and to accept objectivised approach.

Another issue regarding the application of the evaluation method is the evaluation of the quality of components of a complex object with a multi-level structure. In this structure, there occur, e.g., relations between whole and part, as well as cause and effect. The assumption regarding the superiority of the whole and subordination of the part in the system of all levels of object complexity should not raise any controversies. Therefore, the quality of part should be evaluated by virtue of the evaluated quality of whole with a higher level of complexity. A similar solution applies to the following relation: cause *R* effect. The quality of a component acting as cause should be evaluated by virtue of the evaluated quality of another component that acts as an effect. Based on the above, the quality of all object components is, in consequence, evaluated by virtue of the valued quality of the object.

5.10. Optimisation principle

The optimisation principle is a logical continuation of the evaluation principle, and its methodological foundations are discussed in subchapter 4.5. As opposed to the evaluation principle, which applies to all objects, the optimisation principle pertains only to the creation of artificial objects. Optimisation should be an inherent feature of actions, as in ultimate consequence it assures as high, and growing, quality of life as possible. As a result of the application of this principle in the manufacturing sphere, the optimum quality of artificial object is achieved instead of any or accidental quality. The essence of this principle is the creation, and then value-based hierarchisation of sets of allowed solutions to specific qualitative problems based on the objective function, which, in consequence, leads to choosing best solutions.

In an analytical approach, optimisation is a permanent element of any organised decision-making process, thus lending it the features of methodological and substantial rationality. High level of methodological rationality is achieved when the choice, as the final event in the decision-making process, is fully based on the existing knowledge of optimisation methods and on gained knowledge of conditions that make up the decision-making conditions. As this knowledge is in practice somewhat limited, uncertain or untrue, methodological rationality does not guarantee directly substantial rationality which, by assumption, results from competent application of the best optimisation method while having full, objective and certain knowledge of the decision-making situation (see [38, p. 89]). The growing similarity of both types of rationality is a function of science development and improving cognition of reality.

It transpires from the nature of quality that the problem of quality optimisation occurs as a multi-dimensional decision-making problem, while the size of the set of qualitative categories as decision-making variables in the optimisation model serves as a measure of a task's difficulty. The optimisation process itself belongs to the preparation stage and has an anticipatory character in relation to the executive stage of shaping object quality. Optimisation of quality occurs primarily in the **processes of artificial objects design**. Optimisation of design quality should take into consideration the entirety of projected and planned conditions of the entire life cycle of a specific artificial object. Concurrently with the passage of this cycle, the optimisation process of design quality occurs, which consists in making qualitative changes in line with the changing, planned, projected and non-projected conditions of the cycle.

A phenomenon of multiple relativism occurs in the optimisation of artificial objects quality, the source of which may be any of the components of the optimisation model. The changes in the objective function, limitations, and decision-making variables, occurring or conducted, cause changes in optimum solution. An indirect cause of relativism is time over which the objective changes in the optimisation situation occur.

If the projected variants of optimisation situation have been organised according to their probability, then, analogically, optimum solutions corresponding to these variants will be organised. It is also recommended to determine optimum solutions for the most favourable (optimistic) and least favourable (pessimistic) and averagely favourable variant of an optimisation situation. Aggregated analysis of probability and favourability should lead to choosing a solution which best fulfils these criteria. A simplified set of variants in such an analysis is presented in the following matrix:

Criteria of analysis		Probability of occurrence of optimisation situation variant		
Favourability of optimisation situation variant		high	medium	low
	high	hh	hm	hl
	medium	mh	mm	ml
	low	lh	lm	ll

(5.9)

The best variant of a situation occurring while solving an optimisation problem is, by virtue of the criterion of favourability and probability of meeting, the variant marked with symbol mm.

Another type of changes in the model and variants of optimum solutions includes volitional changes, introduced by the decision-making entity as a result of changing the entity's system of values, beliefs, attitudes, and knowledge resources. The entity may change and use variants of the objective function, decision-making variables, and limitations, to the allowed extent. If an entity applies many objective functions, then an attempt to hierarchically organise these functions and corresponding optimum solutions may be made. In order to do this, a superior criterion is necessary, which may be referred to as the **objective metafunction**. One of the methods to create objective metafunction may be proper aggregation of the subordinate objective functions. In the established hierarchical order, solution ranked as first will be the optimum one.

The issue of optimisation occurs, by assumption, in situations wherein many allowed solutions exist, the scope of which may be, to a certain extent, increased or decreased. This specific relativism is expressed by a hypothesis that the generation of a larger number of allowed solutions increases the probability of finding the most favourable one. Therefore, the postulate of applying and increasing the number of variants of solutions to qualitative problems is well-founded.

In creating the objective function in optimisation model quality models may be used, which have the function of a positively-oriented system of reference. One of the possibilities is adopting an adequately formulated distance to the model as an optimisation criterion. An optimum solution will be an allowed solution of smallest distance. The measure of distance will depend, *inter alia*, on the applied model (see Item 4.4). The optimum solution selected ultimately in the design stage constitutes the optimum model of quality of an artificial object for consecutive stages of its life cycle.

In economic practice, artificial objects (e.g., products) are manufactured by unit, in serial or mass production. These circumstances result in a fact that, apart from the quality model and design quality, there occur also actual quality, manufacturing quality, sets of deviations of states of common features and qualitative homogeneity of product, which also constitute an object of optimisation. The diagram of the system of product quality categories is presented in Fig. 5.4.

Optimisation of a product's design quality in line with the above diagram consists in determining such a set of deviations of states of common features of design quality against model quality, which meets a specific extremum (maximum or minimum) of the assumed objective function. Optimisation of manufacturing quality leads to establishing such a set of deviations of states of common features of actual quality of specimens or product series against design quality, which meets a specific extremum of a specific object function. Optimisation of actual product quality is equal to the optimisation of manufacturing quality, as actual quality may be explicitly determined based on design and manufacturing quality.

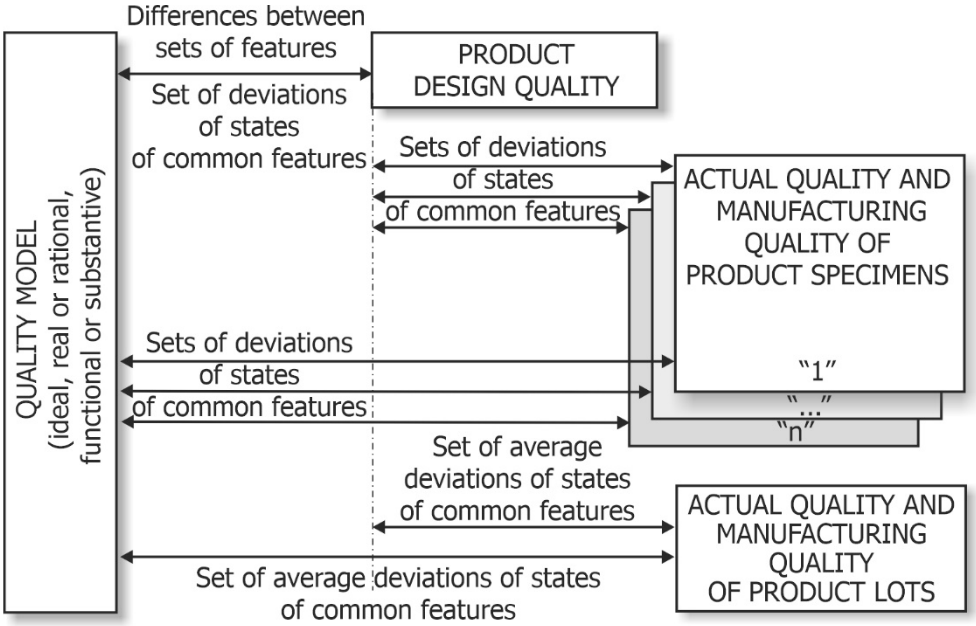

Fig. 5.4. Diagram of product quality categories system [17, p. 47]

As results from the above methodological tips, the aforementioned deviations are an object of optimisation (decision-making variables) and not an objective function. Optimisation of qualitative homogeneity leads to establishing such a set comprising states of measures of dispersion states of common features of product specimens' actual quality which meet the specific extremum of assumed objective function. When creating the objective function for manufacturing quality optimisation models and qualitative homogeneity of products, economic categories may apply (Item 5.12).

5.11. Standardisation principle

In a general approach, standardisation results from the need for reasonable **limitation of possible diversity** in the shaping of artificial objects' quality. If, while learning the quality of natural objects, the situation of infinite diversity of their quality should be regarded as obvious, allowing indefinite diversity of quality in manufacturing activities is met with execution, effectiveness, efficiency-related, economic, and other barriers.

The standardisation of artificial objects quality (e.g., wares, services, notions, technologies, activities, processes, parameters) consists in rational limitation and reasonable selection, for execution, of only specific states, ranges or artificial object quality trajectory from a usually indefinite set of possible states or trajectories. With respect to quantitative features, a continuous result of standardisation is their **discretisation**, consisting in the transformation of these features into quantitative discreet features of limited variability range. As the manufactured quality of artificial objects should, by assumption, be adequate to the specific needs and resulting specifications of requirements, then the initial object of standardisation covers specifications of requirements.

A qualitologically expressed, universal **object of standardisation is the quality of artificial objects**. On the other hand, **standards**, which occur as principles, procedures, models, rules, methods, levels, plans and as many other forms of expressing selected quality states, trajectories, thresholds or ranges regarding a specific object of standardization, are a universal result of standardisation. Standards are designed for multiple or continuous use by organisations that accept them. Depending on the class of standardisation objects, there may be the following standards: semantic, operational, substantive, classification, legal, technical, organisational, economic, linguistic and many others, corresponding to specific classifications of standardisation objects. It may be assumed that the entire activity of any organisation may be treated as an object of standardisation, although the tradition of standardisation is dominated by products and manufacturing processes, technical conventions, research methods, acceptance and marking procedures[16].

The indicated premises suggest that for a general interpretation of standardisation, the qualitative approach to its object is adequate and best expresses the sense and scope of this activity. The proposed descriptions of three basic terms within this range, corresponding to this approach, are as follows [17, p. 108]:

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[16] Specific manifestations of standardisation in technology include standardisation and unification of wares and technological processes.

Description 5.3. **Standardisation is the development and application of standards.**

Description 5.4. **Object of standardisation is an artificial object the quality of which is postulated and deliberately limited.**

Description 5.5. **Standard is a document containing agreements regarding the postulated and deliberately limited quality of an artificial object.**

Based on the above descriptions, the essence of the application of the standardisation principle dwells in a rational limitation of qualitative diversity of artificial objects using norms, which may be referred to as **quality standards**. Therefore, qualitative categories play the function of a universal object and carrier of any standardisation regulations. These regulations should be purposeful, reasonable, and optimised using, *inter alia*, principles of evaluation and optimisation (Item 5.9 and 5.10).

The main, synthetic, and universal purpose of standardisation is the rationalisation of diversity and best possible adjustment of artificial objects quality to specific needs and resulting requirements. The process and results of this adjustment are subject to reasonable limitations resulting from efficiency, effectiveness, and protection-related premises.

Efficiency and **effectiveness premises** express positive results of limiting the diversity of artificial objects quality which occur in the manufacturing and operating processes. The favourable influence of the standardisation of wares quality and technology on the technical, economic, and useful effects: specialisation, concentration, and manufacturing scale, replaceability of parts, improvement of logistic, handling and repair operations.

Protection premises are related to the need to establish a collection of threshold states or allowed range of values of an artificial objects, assuring the required level of meeting the need, as well as a collection of threshold states or allowed ranges of drawbacks, protecting entities and their environment against the negative impact of artificial object's existence.

An exhaustive analysis of the standardisation problem should take into consideration the balance of benefits and losses resulting from such activity. Undoubtedly, standardisation is a necessary tool for shaping of object quality, introducing various limitations to the freedom of choice. These limitations lead to the elimination of free choice of qualitative solutions and the introduction of a **set of normative solutions**. However, unfounded limitation of quality diversity, *inter alia*, narrows down the qualitative diversification of artificial objects, which is expressed by the number of types, varieties, versions, classes, species etc., which may in consequence decrease the level and effectiveness of meeting specific needs. Hence a conclusion that the scope and number of limitations established as part of quality standardisation are optimised variables. Premises related to the level of satisfying needs and meeting requirements weigh in favour of decreasing the scope and number of limitations, and for increasing – efficiency and effectiveness-related execution and protection premises.

There are many other positive results that fall under benefits in the standardisation balance. An inherent feature of standardisation is the optimisation of decisions regarding qualitative limitations. This assures that the limitations of shaping the quality of artificial objects contained in standards have been comprehensively studied, analysed, and optimised. It helps entities in making qualitative decisions. The management and executive operations in organisations, in line with external and internal standards, assure **repeatability**, **stability** and **homogeneity of quality** of product specimens manufactured in series or mass production. The occurrence of these effects assures, i.e., the substitutability of product specimens in fulfilling utility functions, as well as facilitates operational processes and limits their uncertainty (e.g., replaceability of parts, standardisation of operating processes). Standards are inherent elements of internal and external quality assurance and relationships with partners.

The standardisation principle also has a positive function, as it leads to the formalisation and documentation of the quality of activities in organisations. These operations pertain mainly to typical and repeatable activities. The formalisation and documentation of activities contribute to such favourable phenomena as: thorough analysis of problems, explicit transfer of exhaustive information, optimum organisation of objectives and operations, making comprehensive arrangements, facilitation of control and enforcement of liability, mitigation of errors or facilitation of training. Activity based on standards is a contradiction of freedom and using the trial and error method. Well-developed quality standards are models for optimum and effective activities aimed at the satisfaction of the needs of members of specific organisations. Proper standardisation also takes into consideration the priorities of customers of the organisation and the interests of other entities in its environment, while performing promotional and competitive functions.

Standardisation also assures the harmonisation, unification, and qualitative compatibility in sets of manufactured artificial objects. The need for **harmonisation** results from the occurrence of mutual relationships of objects and associated qualitative categories; the need to **unify** – from diverse qualitative requirements and the purposefulness of their arrangement, and the need for **compatibility** – from the schemes of complementary objects.

Standardisation may also have negative effects. Primarily, it may over-limit the creative decision-making freedom of designers, programmers, planners, managers, and other subjects. Standardisation, when handled improperly, creates favourable conditions for excessive bureaucracy and shakes the balance between the formal and substantive side of its regulatory functions. An **over-regulation phenomenon** may occur, which consists in excessively detailed and omni-present standardisation of quality, with excessive stress put on control activities in the enforcement thereof.

Formalisation which accompanies standardisation is favourable for routine in operations, which may hinder invention as well as creation and implementation of innovations. It is feared that standardisation hinders technological and organisational progress and leads to over-stiffening of organisation and losing the necessary flexibility and speed in responding to changes occurring in the organisation and its environment. Standardisation, when unreasonably over-elaborate, causes higher costs and slower operation, dramatic increase in information and documentation as well as "red-tape" style of work and degeneration of substantive liability for the actual quality of actions. There is a conviction that standardisation itself by default guarantees proper quality at minimum involvement, invention, and effort of members of the organisation[17].

Another threat related to standardisation is the impediment or even impossibility of cooperation and mutual exchange of products resulting from a dispersed, independent, and non-arranged standardisation actions undertaken by organisations. Therefore, joint and arranged standardisation efforts are necessary to assure **coherence**, **harmony,** and **uniformity of the standardisation system** on a scale larger than frameworks of individual organisations.

The subjects of standardisation activities include autonomous organisations, which operate as enterprises, holdings, state and international institutions, associations, scientific units, societies, and other types of organisations. Each autonomous organisation has a right to establish standards and implement them in the area of its impact and rights. The importance and authority of an organisation in this respect depend proportionally on the range of application of standards developed by the organisation. Standards designed for internal use of an organisation are developed and implemented

[17] In that case, a question may arise in the practice of quality management in organisations: if we have so good standards and quality management system, why are our qualitative and market results so poor?

in line with the adopted management system. On the other hand, external standards implemented in an organisation are basically [65]:
- **obligatory**, the application of which is required under law enacted by competent state authorities,
- **optional**, applied under any concluded agreement, fixed tradition, or universally adopted convention.

Standardisation occurs in all types of organisations but has particular importance in economic organisations. In the economy, it has significant effects in the areas of technology, economics, natural and social environment, is an object of comprehensive studies, has long tradition and developed organisational structures. In standardisation activities in the economy, the following levels and subjects that handle them can be distinguished [46]:
- industry standardisation, handled by enterprises, their unions and non-government standardisation associations,
- national standardisation, handled by government or authorised (accredited) institutions in line with established legal order,
- trans-national standardisation handled by international organisations (associations, federations) of various range of impact.

Standards developed on the above mentioned levels are optional, except for some national standards. The dispersion and freedom of creating industry standards resulted in considerable diversity of technological requirements in individual countries which significantly hinders the economic integration processes in existing communities and on a global scale. Industry standards gain their position and recognition depending on their merits and authority of organisations that develop and apply them. Therefore, standards of huge manufacturing or trading leaders in their industries (branches, sectors) enjoy high status. In-house schemes of standards are created as part of huge manufacturing and utility structures, such as communications, railways, the military, or health service.

In industry standardisation, a significant role is played by insurance companies and renown associations of experts in technology. These organisations co-participate in the creation of technological conventions, requirements, procedures, testing methods or classifications, as well as draw up expert opinions, conduct research and issue approvals (certificates). Sometimes standardisation associations are accredited by authorities and gain exclusive rights to handle standardisation activities in a given state. Industry standards are one of the major elements taken into consideration during negotiations and conclusion of trade agreements. Under these standards, the manufacturer is liable, under civil law, for the quality of supplied products and meeting the remaining technical terms of agreement.

The state standardisation level should support and harmonise industry and trans-national standardisation, as well as protect the general socio-economic interests. Supporting and harmonising state standards are usually optional, and protectiveones – obligatory. One of the objectives of state standardisation is also the expansion of the compatibility of standards. In most countries the obligatory state standards cover the protection of life and health, occupational health and safety and use of goods, protection of natural environment, agricultural crops and animal breeding, products ordered by state organisations.

Objects of national standardisation which are particularly useful for quality engineering include: **measurement system** (legal units of measure, metrological control of measuring devices, supervision, etc.) and **research and certification system** (awarding a safety mark, accreditation of certification bodies, certification of auditors, accreditation of research institutions etc.). The obligation to obtain safety mark for specific products is common. The mark attests that the product is not a threat to life, health, properly or natural environment. Obligatory national standards apply equally to domestic and foreign entities, thus limiting their freedom in the area of manufacturing and trade. Adherence to these standards by the manufacturer exempts them from financial liability for losses resulting from the use of product. A national standardisation authority usually uses the support of organisations authorised to handle standardisation activities in strictly defined thematic scopes. They may include competent enterprises, science and technology associations, consumer organisations, research and development bodies and other entities.

Organisations operating on the level of trans-national standardisation aim at the unification and harmonisation of strongly diversified and incoherent levels of industry and state standardisation in individual states of specific international communities. Special emphasis is put on standardisation activities and the need to standardise them in the European Community countries. There, standards are regarded as an important factor of **qualitative progress** and breaking barriers in the integrating and expanding single market. Many international organisations (e.g., ISO, CEE, IEC) and federations of national standardisation associations (e.g., CENELEC, CEN) operate on the level of trans-national standardisation. These institutions usually adopt a negotiating procedure of drafting standards (directives) and a democratic method of adoption (in a vote). They are not government institutions and the standards they adopt are not obligatory. These standards may be introduced in individual states, in relevant procedures. Centralising tendencies aimed at strengthening the position of European standards (EN) are visible.

It is intended to establish a European accreditation system to facilitate the recognition of certificates issued in individual states in the Community. This problem is handled by the European Organisation of Technical Approvals. There is a European system for notification of organisations that issue safety approvals (CE mark), exempting manufacturers from the obligation to obtain these approvals in individual states [17, pp. 108-113].

High priority assigned to standardisation in the European Community led to the fact that also **quality management** became an object of standardisation. In 1987 an unprecedented event was recorded – the International Standards Organisation adopted and recommended for global application the ISO 9000-9004 standards along with terminological standard ISO 8402. These standards contained solutions regarding quality management, with particular attention paid to quality assurance. These regulations were adequate to the specificity of operation of manufacturing enterprises. Despite their descriptive and not very comprehensible nature, these standards were adopted as national standards in several dozen countries. They were widely applied when concluding contracts wherein the manufacturer demonstrated the capacity to guarantee the postulated, stable, and homogeneous quality of the subject of the contract. These standards performed the substantive and promotional function, simultaneously showing the European path to TQM.

Since 1987 the Technical Committee ISO/TC 176 has handled standardisation works related to the improvement and development of quality management system. Also, the whole infrastructure strengthening the stimulation to implement quality management system in various organisations is being developed. A vital element of this infrastructure is the bolstering of systems of assessments and certification of implemented quality management systems and a system for accreditation of certification bodies. A quality training system is being dynamically developed and propagated. Systematic updates of quality management standards are being planned and implemented.

It should not be a controversy to conclude that the broadly understood standardisation is an important **management tool**, in particular in quality management. There are premises for the creation of a new method of management in organisations, which may be referred to as "standardisation-based management". It is not possible to perform planning, organisational, leadership, control, and improvement functions in quality management without standardisation assuring, i.a., proper level of formalisation and documentation of actions. In quality management, the functions of standards are also performed by such documents as: plans, programmes, designs, specifications of requirements, rules, duty registers, quality manuals, procedures, contracts, instructions, and industry, national and international standards. Each document which determines postulated quality of any object of management performs in fact the function of a standard. One of the problems falling under the competence of the management system is the avoidance of threats indicated earlier, related to the application of the standardisation principle.

5.12. Economics principle

The activities of entities in money-goods market economy create a need for considering quality on the economic level. The intensity of this need depends on the degree of economic autonomy of entities and on the nature of market self-regulation mechanism and interventionism. Economy dominated by private ownership, market that is demonopolised and dynamically balanced in favour of demand, and interventionism that protects the market, interests of customers and natural environment positively stimulate the development of economic research of quality at the level of manufacturers and sellers. Such an economy creates an economic compulsion to apply the following orientations:

- **pro-quality**, assigning high priority to the problem of quality of actions and products (wares, services and works) as well as total quality management,
- **pro-efficiency**, awarding utmost importance to the issue of achieving economic goals.

These orientations are related to the well known regularity in line with which the successes and fate of market entities depend primarily on to what extent they can face growing competition based on **quality** as well as **cost and price**.

The programme and results on operations of a market entity, in particular a business organisation (enterprise), are reflected in the planned, and then achieved, **economic goals**. **Planning accuracy** and **effectiveness of achieving** these goals determine the financial standing of the enterprise and form the primary grounds for the assessment of its operation, including quality management. The pecuniary dimension of economic goals makes them the best indicator and measure of consequences of decisions and undertakings made, including qualitative decisions and undertakings. The organised chain of six main economic goals of an enterprise, as to which there is legitimate assumption that they depend on the quality of its manufacturing operations, is presented in Figure 5.5.

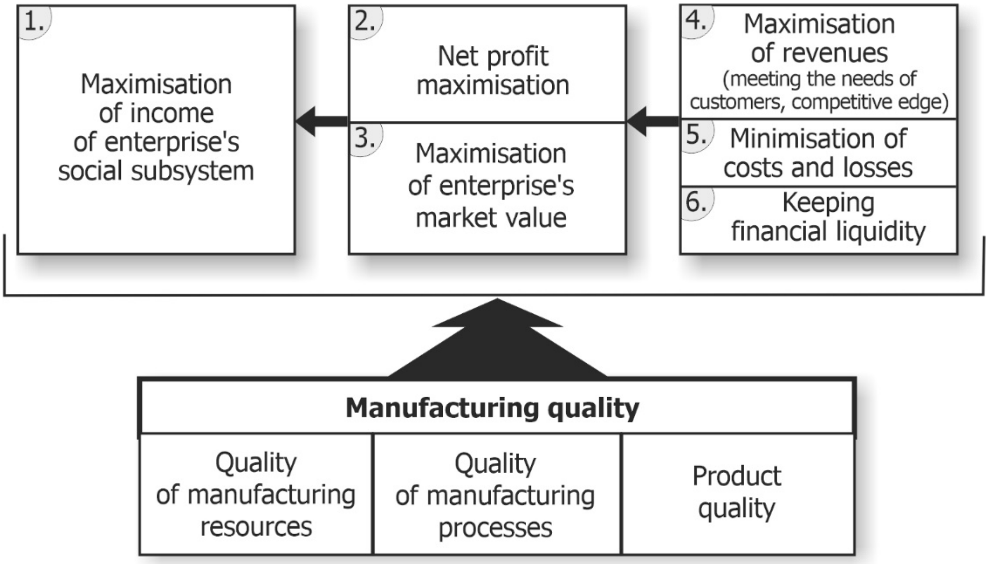

Fig. 5.5. Economic goals of an enterprise depending on the quality of manufacturing operations

An important merit of the mechanism of correct market self-regulation in economy is the assurance of the inevitability and specific objectivity[18] of the dependence between quality of products (object of exchange) and their value in monetary units. Thus, the quality and price policy of vendors and behaviour of customers depend on market relations between product quality and price. Making market prices dependant on product quality means that the **economic evaluation of quality** occurs on the market. Therefore, the category of market price has the function of an economic feature of value in the processes of evaluation of product quality within the framework of market self-regulation mechanism. This type of evaluation generates a pro-quality economic pressure with respect to vendors and strengthens qualitative competition. By differentiating the prices of products of different quality, market makes quality a self-contained commodity. Thus, there emerge premises to treat **quality as a measurable economic goal** which has a positive impact on achieving economic goals (e.g., goals 6, 4, 3, 2, and 1 in Fig. 5.5).

[18] The specific nature of objectivity consists in that market price of the object of exchange, which is dependant on its quality, is a mean result of many individual evaluations of quality made by customers.

Product quality which has a specific market value does not occur without any labour and other efforts related to the manufacturing thereof[19]. Therefore, designing the product and execution of manufacturing processes, as well as achieving the postulated quality are absolutely related to the need for outlays and incurring costs and losses. Thus, the quality of manufacturing activities and products becomes a factor affecting the achievement of part of economic goals of manufacturing entity (e.g., goals 6, 5, 2 and 1 in Fig. 5.5).

Based on the above deliberations, the joint impact of the quality of actions and products on the economic goals of a vendor is bi-directional – positive and negative. Studying and then using the dependence between the quality of actions and products and the economic goals of an enterprise is the basic source of economic problems in quality management.

The entirety of economic issues of quality is being studied by the **economics of quality**, as an important section of qualitology (Item 2.5). The needs of entities and significance of this topic for the economic effectiveness of their operations are considerable. At the same time, one can notice absence of methodological perspective of formulating and solving quality-related economic problems [60]. The current achievements of quality are dominated by the topic of the so-called **costs of quality**, limited to the costs and losses due to faulty manufacturing which expressed one of the aspects of manufacturing quality [60, pp. 58-212][20]. The improvement of this unfavourable state, assuring also opportunities for further development of economics of quality, should be started with outlining the possibilities of expanding the spectrum of quality-related problems (see Fig. 5.6).

A condition precedent for the emergence of quality-related economic problems is the occurrence of a set of relations ($\mathbf{R}_{je}$) between qualitative and economic categories:

$$\left\{ \begin{array}{c} \text{Qualitative cate-} \\ \text{gories of object} \\ \text{belonging to set} \\ \mathbf{K}_j \end{array} \right\} \quad \begin{array}{c} \mathbf{R}_{je} \\ \Leftrightarrow \\ \downarrow \\ \text{Identification} \\ \text{Formalisation} \end{array} \quad \left\{ \begin{array}{c} \text{Economic cat-} \\ \text{egories from} \\ \text{set } \mathbf{E}_i \end{array} \right\} \qquad (5.10)$$

In general, one should assume the possibility of occurrence of bilateral relations, wherein qualitative and economic categories alternately function as dependent and independent variables or causes and effects. The first party to the relation reflects the impact of qualitative categories of a given

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[19] In qualitological interpretation, manufacturing of a product is equal to the manufacturing of its quality.

[20] The provisions of international ISO 9000 standards also accepted this unfavourable state of affairs and thus it has been preserved.

object on specific economic categories, while the latter – the other way round. The manufacturer's quality management is dominated by problems caused by the first party to the relation, as the core business concentrates on design and then manufacturing of products of adequate quality.

The studies of relation $\mathbf{R}_{je}$ aim at the discovery, identification, and formalisation of dependence between qualitative and economic categories referred to the specific object. It is favourable, if the studies allow the empirical determination of analytical forms of the dependence functions, wherein economic categories are dependent variables, and qualitative categories – independent variables, or vice versa. The usefulness of these functions in quality management grows as the accuracy, precision, and objectivity of representing actual causal connections and functional dependences increase. The general notation of the above functions is as follows:

$$e_i = f_i(k_1, k_2, k_3, ...k_j) \text{ or } k_i = f_i(e_1, e_2, e_3, ...e_j) \qquad (5.11)$$

where:
e_i, k_j – respectively, economic, and qualitative dependent variable,
$\{k_1, k_2, k_3, ..., k_j\}$, $\{e_1, e_2, e_3, ..., e_j\}$ – respectively, set of qualitative and economic independent variables.

In the studies of dependences and in formulating functions, both qualitative and economic categories may occur in the full spectrum of their types, levels of aggregation as well as analytical and synthetic forms. No *a priori* restriction of this possibility is justified. The assumed solutions in this respect depend on the characteristics of a specific research situation, in particular on the needs of quality management, as well as research objectives, methods, and possibilities.

It is difficult to enumerate all economic categories that may hypothetically demonstrate a causal or functional connection with qualitative categories. Their identification, classification and structuralisation are carried out in specific research processes. Examples of economic categories that may be used include: cost, loss, price, revenue, income, profit, financial result, remuneration, profitability, cash bonus, tax, depreciation, operating cost, financial penalty, demand, economic effectiveness, and many more. An analogous situation occurs for qualitative categories, which may include, for instance: quality, feature, state of feature, intensity of feature, level of feature, state of quality, design quality, manufacturing quality, defect, incompatibility, comprehensive quality, reliability, functionality, durability, ergonomics, tolerance of feature, and many more.

The economic categories dependent on the quality of enterprise's operation express the interests and goals of entities that are directly or indirectly related to product manufacturing or operating processes. In reference to the quality of a specific product, these will be all entities related to its life cycle. The economic consequences of quality arising at manufacturer's as the entity that is to the largest extent responsible for the comprehensive product quality, are most often and strongly stressed. The pressure to use marketing orientation results in the fact that the impact of product and service quality on economic goals of customers are researched more frequently. The interests and goals of entities from social environment are usually taken into consideration by the manufacturer to the extent that there is pressure and financial sanctions provided in the binding legal regulations (e.g., in respect of protection of life, health and natural environment). The specific nature of the buyer's market causes that, in quality management, the manufacturer is relatively the most stimulated to take into account their customers' interests and the least – the interests of their vendors.

Therefore, in quality management there are problems related to consideration and hierarchisation of economic goals of many entities and harmonisation thereof, i.a., through neutralisation and compensation of conflicting interest. The fundamental role in properly solving these problems is played by system-based external conditions which influence the operation of any entity. These conditions are determined mainly through the quality of market mechanism and interventionism.

The application of the economics principle in quality management causes the need for identification and organisation of the economic issues of quality. The proposal of a basic division of these issues according to the characteristics of tasks in quality management is presented in Fig. 5.6.

Re: 1. The first group of issues pertains to gathering economic knowledge of quality management conditions. The qualitative decisions made and then implemented are based on a specific set of economic output premises and cause, in general, a series of direct and indirect economic consequences, dispersed in the organisation and its environment. Input premises include economically expressed **requirements, limitations, opportunities,** and remaining data. These premises are useful in the determination of a set of allowed solutions to qualitative problems. Both premises and consequences should be identified in order to take them into consideration when making, assessing, and verifying qualitative decisions. Identification of a relation between specific economic conditions (premises and consequences) with decision made alone is insufficient and it should be attempted to identify this relation, preferably in the form of formalised dependences. Objective research, accurate identification and thorough analysis of economic conditions provide sound grounds for making decisions regarding all quality management functions.

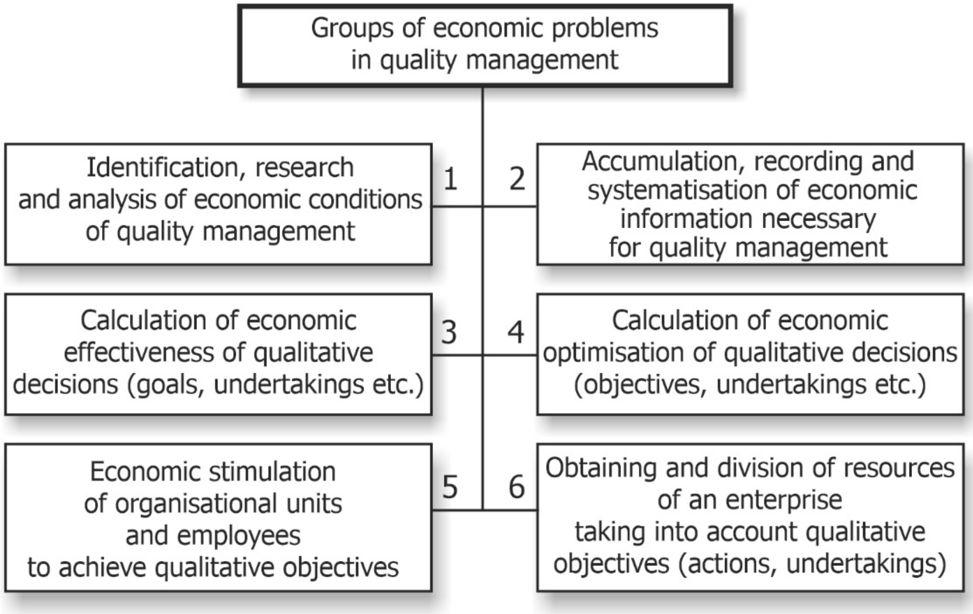

Fig. 5.6. Division of economic issues in quality management

Re: 2. Issues belonging to the second group are related to building an economic information system in an organisation, corresponding to the requirements of the quality management system. Building such a system is not an easy task, mainly due to the dominating, in practice, combination of economic categories with quantitative characteristics of operation of organisations. The economics of quality has not built sufficient methodological foundations to relate the economic and quantitative approach with the qualitative approach of the operation of an organisation. There are only attempts to develop a partial solution to this complex problem in the framework of the account of **incompatibility costs**, commonly referred to as costs of quality. A thesis may be formulated that only after demonstrating the legitimacy and methodological approach to qualitative objectives, undertakings and tasks as economically measurable goals of an organisation (analogically as for goals expressed quantitatively), there will be premises for a drastic transformation of the economic information system in organisations, in line with the needs of the quality management system. In this respect, initiative will be held by the quality service, closely cooperating with the economic, financial and accounting services. An adequate economic information system should deliver objective, full, accurate and multi-sectional internal and external information necessary for quality management. Most of all, the quality of this information determines the accuracy of solutions to problems belonging to group 3, 4, 5 and 6 (Fig. 5.6).

Re: 3. Adherence to the principle of reasonable resource management and natural drive of entities to achieve economic goals requires the application of economic criteria in qualitative decision-making. Economic criteria (though not only them) in money-goods economy usually comprise the principal grounds for these decisions. It is highly likely that the methodological grounds for the calculation of economic effectiveness of qualitative decisions are coincident with the universal methodology of calculation, adequate to all types of decisions made by entities. The basis for this methodology is the **principle of comparison** expressed in categories of **positive** and **negative** economic consequences and premises for a specific decision. The premises and consequences directly take into consideration the goals of the decision making entity and indirectly also the goals of other stakeholders. The comparison principle requires the division of the premises and consequences of a specific qualitative decision into two groups:

- having a **favourable** (positive, constructive) impact on achieving the economic goals of an entity,
- having an **unfavourable** (negative, destructive) impact on achieving the economic goals of an entity.

The premises and consequences of the first group comprise a general economic category of **effects**, whereas the premises and consequences of the latter – a category of **outlays**. Effects and outlays expressed in specific economic categories, in monetary or natural units, are then compared in quotient or differential forms [17, p. 156]:

$$e_j = \frac{E(K_j)}{N(K_j)} \text{ or } e_j' = E(K_j) - N(K_j) \tag{5.12}$$

where:

e_j, e_j' – respectively, quotient and differential indicator of the economic effectiveness of qualitative decision,

$E(\mathbf{K}_j)$ – sum of effects of qualitative decision referred to an object identified by a set of qualitative categories $\mathbf{K}_j$ as independent variables,

$N(\mathbf{K}_j)$ – sum of outlays resulting from a qualitative decision referred to an object identified by a set of qualitative categories $\mathbf{K}_j$ as independent variables.

Indicators e_j and e_j' are used for absolute and relative assessment and verification of economic effectiveness of qualitative decisions. In the studies of **cost-effectiveness**[21], the absolutely effective is a decision for which the indicators take on the following values: $e_j > 1$, $e_j' > 0$. In the research of **economisation**, a decision which in the set of decision variants or in a situation of assessing the effectiveness of changing qualitative categories (assessment of given qualitative categories of an object made before and after the change) has the highest e_j or e_j' indicator is regarded as relatively effective.

Range of perception of indicators e_j or e_j' depends directly on the assumed range taken into consideration in the calculation of premises and consequences of a specific qualitative decision. Firstly, the premises and consequences regarding an entity making the qualitative decision will be taken into consideration, and then – those related to entities from closer environment, lastly – related to entities from farther environment.

A simplified procedure of the calculation of economic effectiveness of qualitative decisions is presented in Fig. 5.7.

In the operation of manufacturers, the calculation of economic effectiveness pertains mainly to the following types of decisions:

(a) determining quality and state of design quality, as well as quality and state of manufacturing quality of specific products that are objects of quality management,

(b) determining changes in quality and state of design quality, as well as changes in quality and state of manufacturing quality of specific objects of quality management.

The type (a) decisions consist in selection of features and their states assigned to a specific product, adequate to the set of conditions, taking into account the design and manufacturing approach. In this situation, the economic assessment is supposed to provide answers to the question whether or not the decisions regarding quality and state of quality of resources are profitable for the manufacturer. Type (b) decisions consist in adding or removing features and changing states of features of a specific quality management object, also taking into consideration and design and manufacturing approach. The economic assessment of these decisions answers the question whether or not it is profitable for the manufacturer to introduce specific qualitative changes.

[21] Cost-effectiveness is the relation of the effect (useful result) to the outlays (costs of achieving the result), and economisation is the process of growth of this relation.

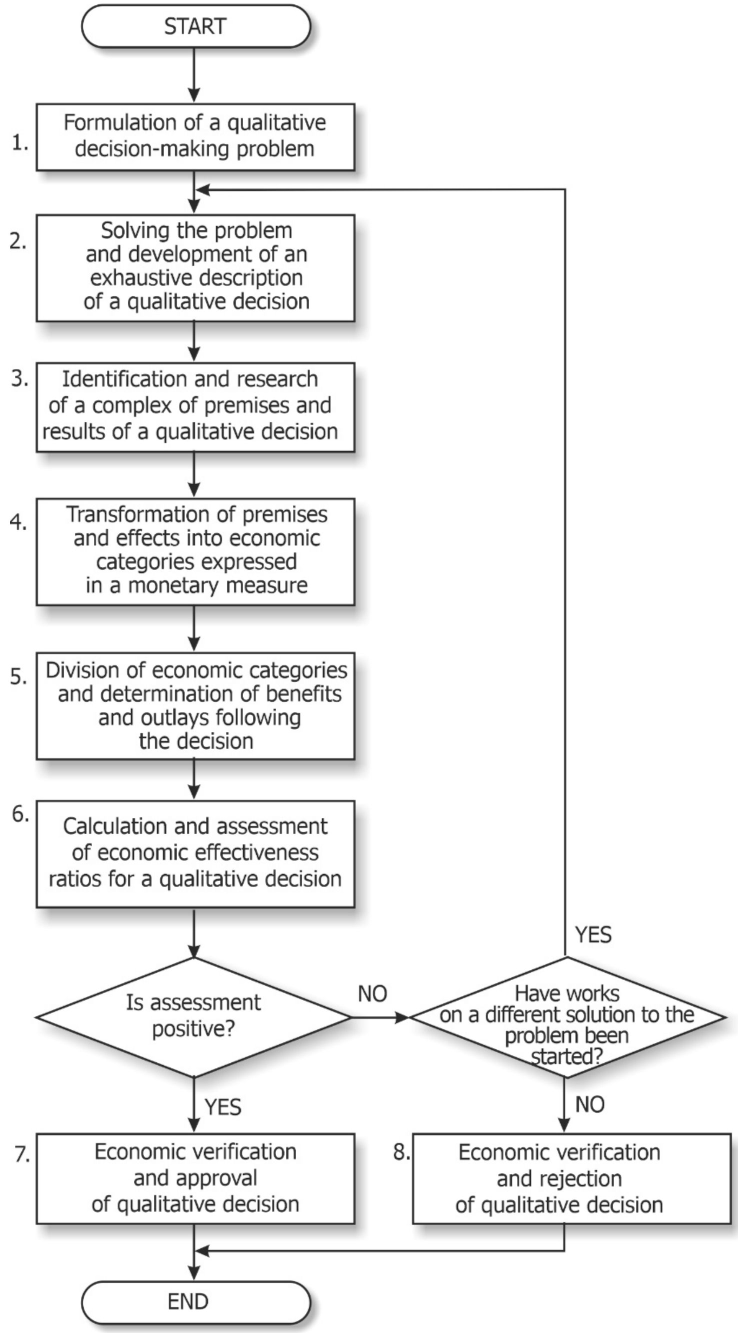

Fig. 5.7. The general procedure of calculation of economic effectiveness of a qualitative decisions, actions, and processes as well as products

Re: 4. The fourth group of issues pertains to the economic optimisation of qualitative decisions, consisting in permanent taking actions aimed at determining most favourable economically solutions to qualitative problems adequate to the changing external and internal conditions. Such optimisation is an effective tool for using the principle of **continuous quality improvement,** which is one of the quality management functions, in positive feed forward with economic goals of an organisation. This feed forward is demonstrated by the occurrence of economisation in quality management.

The economic optimisation calculation is related to building, and then solving a model wherein **specific economic categories function as optimisation criteria**, whereas qualitative categories – as decision-making variables. The model solution leads to determining an optimum of sub-optimum scheme of qualitative categories, for which the assumed economic optimisation criteria gains the most favourable state. It is beyond doubt that the optimisation calculation uses the calculation of economic effectiveness of qualitative decisions. Indicators calculated based on formula (5.10) may be used as optimisation criteria. A practical example of economic optimisation is the commonly known process of searching for product manufacturing quality according to the minimum sum of incompatibility costs.

Re: 5. The effectiveness of quality management in subjective organisational structure requires **economic stimulation** as one of the main components of management leadership function. The sense of economic stimulation comes down to using economic categories as **stimuli** in influencing organisational units in order to perform tasks and achieving qualitative goals coupled with the economic goals of an organisation. By choosing economic stimulating variables, one should have in mind the managed sub-system's sensitivity to these variables, as the effectiveness of the given variable depends directly on the level of sensitivity. The stimulation mechanism should be accurate so as to avoid any doubts regarding the dependence of stimulation variables on the qualitative results of the operation of the managed subsystem. The general notation of the pro-quality function of economic stimulation is as follows [17, p. 159]:

$$S_{ej} = f_{sj}(z_{j1}, z_{j2}, z_{j3}, ..., z_{jn}) \tag{5.13}$$

where:

S_{ej} – economic stimulating variable,

(z_{j1}, z_{j2}, z_{j3}, ..., z_{jn}) – qualitative tasks, goals, or results in the n number.

The quality-oriented economic stimulation of organisational units may occur in the framework of such management instruments as **inter-company settlements**, **management accounting, controlling, budgeting of**

units and other. In respect of employees, such an instrument is the **remuneration system** which takes into consideration the quality of processes and work results.

Re: 6. Quality management is also the identification of sources and distribution of an organisation's resources, adequate to the established goals, tasks, or quality-oriented undertakings. Correct solutions to problems belonging to groups 1, 2, 3, 4 and 5 assure rationality and effectiveness of using specific resources to achieve planned qualitative goals. The entity usually has a very complex resource structure at its disposal. They are divided into, i.a., material and non-material, as well as material, human, instrumental, financial, pecuniary, informational, raw material resources etc. Time is a specific resource. Resources evaluated at value make up the property of the organisation, the use of which in the operating processes is the reason for costs and losses.

The **cost estimates** of qualitative undertakings, properly drawn up, may constitute an instrument of resource distribution. The design documentation of these undertakings contains the qualitative and quantitative characteristics of necessary resources, which forms the basis for the calculation and expression thereof in monetary units. As results from the above, properly allocated resources are necessary for the execution of qualitative undertakings (as any other undertakings). This, however, does not mean that qualitative undertakings are only sources of costs and losses, as may be deduced from the calculation of incompatibility costs[22].

The economics principle outlined above does not exhaust, so important for practical applications, the issue of linking **qualitology with economics** in order to develop economics of quality.

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[22] A practical example of effect creation is a qualitative undertaking reducing the defectiveness and causing the reduction of total incompatibility costs (cost analysis according to the PAF model – prevention, appraisal, failure).

Chapter VI

SELECTED APPLICATIONS AND FUNCTIONS OF QUALITOLOGY

6.1. Scope of application of qualitology

The developed overview of qualitology demonstrates its **fundamental** and **universal** significance in many other scientific disciplines and fields of practice. Its importance and universal usefulness result primarily from the adopted, overwhelming scope of the object of research and the research perspective, stemming from the foundations of epistemology and establishing a new paradigm in the relation between man and reality, which is referred to as qualitative approach. Qualitative categories are interpreted as elementary cognitive tools of universal application, used for **informative modelling** of any components of reality. In this manner the **qualitative perspective of the view of reality** was developed. All this results in the fact that new, universal opportunities for the application of qualitology are opening up, deviating far from the current ones, which are fragmentary and mostly utilitarian. The scope of effective use of these opportunities depends, however, primarily on further development of the theory of quality.

The to-date achievements and existing conditions of the development of qualitology allow only the suggestion of the most general possible options for putting this scientific discipline to use. Therefore, this book does not offer any exhaustive or multi-faceted presentation of the complex of application fields of qualitology, but rather preliminary results of the attempt to specify certain areas of tasks and functions on high level of generality. This level refers to basic areas of human activity and corresponding goals, tasks and function qualitology may prove useful to achieve.

In the first degree of the division of human activity, two closely connected areas of activity may be distinguished:

- **cognitive**, consisting in continuous and systematic gathering of information and expanding knowledge of reality – applicable primarily to scientific activity,
- **creative and causative**, consisting in the contemplation and deliberate transformation of reality – applicable primarily to practical activities.

Figure 6.1 presents the scope of possible applications of qualitology, related to the aforementioned areas of activity and formulated in the form of selected functions that correspond to selected objectives in these areas.

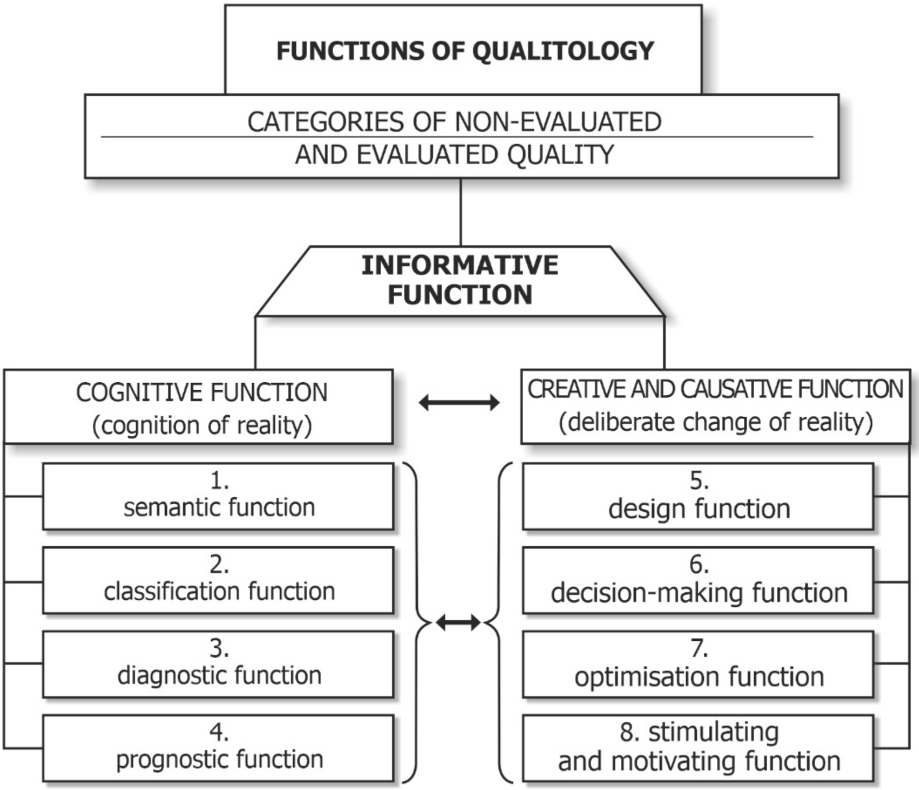

Fig. 6.1. Selected functions of qualitology [17, p. 54]

The superior, general and most universal function of qualitology is the **informative function**. It consists in the scientific creation and assignment of adequate qualities (information models, images, mappings) to specific objects as isolated fragments of reality. Qualitative models of objects may be created in cognitive processes (then the **cognitive informative function** occurs) or in the processes of postulating and actual shaping of object quality (**then the informative creative and causative function occurs**). All functions of qualitology presented in Figure 6.1 pertain to specific scopes of reality and are closely integrated.

Among the enumerated functions of qualitology, two functions deserve a mention due to their importance, namely the semantic function (Item 6.2), applicable to the system of linguistic signs and classification function (Item 6.3), pertaining to all objects. The general characteristics of the remaining functions is as follows [17, pp. 54-58].

Diagnostic function

The diagnostic function is closely related to the qualitological method of acquiring knowledge of reality. The knowledge is retrospective or current in nature. All existing objects were or are in specific schemes, relations and states. The knowledge of objects and informative modelling thereof, in line with the assumption underlying qualitology, is possible as a result of the application of qualitative categories. Therefore, the diagnostic function F_d consists in the adequate assignment of qualitative categories to individual existing and studied objects, which may be in general noted as follows:

$$F_d : \mathbf{P} \to \mathbf{K}_j \tag{6.1}$$

where:

$\mathbf{P}$ – given set of objects,

$\mathbf{K}_j$ – set of qualitative categories.

As a result of the use of the diagnostic function, partial or complex knowledge of objects existing in the past or present is gained. Having such knowledge at disposal enables, inter alia, the **identification** of objects and provides grounds for other operations and functions.

Prognostic function

The prognostic function expresses the essence of the acquisition of prospective knowledge of object quality. It is similar to the diagnostic function but related to objects which were assumed to exist in the future. It is difficult to overestimate the importance of the prognostic function for the effectiveness of meeting the creative and causative functions. Knowledge of objects gained thanks to the prognostic function demonstrates the properties of a hypotheses of known or unknown probability. The retrospective, current and prospective knowledge expressed in qualitative categories reflects the completeness of cognition of objects taking into consideration the time coordinate. Qualitative transformations of objects occurring in these three time ranges are presented as qualitative trajectories.

Design function [40]

The design function applies to design objects and belongs to the group of informative, creative and causative functions. It is made up of creative actions undertaken by designing subjects, direct results of which are the **design qualities** of objects, reasonably adapted to all conditions recognised under the cognitive function. Creative actions are an immanent feature of design and result in the creation of new qualities of artificial objects. The phenomenon of creativity is manifested, in a particular manner, in the form of deliberately shaped qualitative synergy effects (Item 5.6). The degree of innovation of design quality enables relative qualification of artificial objects to the following innovation classes: new generations, new types or new varieties. In general, it may be concluded that new generation results from the discovery and use of new important phenomena and features of objects. New type of an object derives from new combination of known features, and new variety of an object of a new combination of the states of known features.

A single result of actions under the design function is the **design** referred to the future, a qualitative model of postulated artificial object. This model also exercises a function of a model in the processes of manufacturing an artificial object and determines the postulated **common quality** of all product copies. The design function F_{pr} consists in the adequate assigning of qualitative categories to the designed artificial objects. It is generally recorded as follows:

$$F_{pr} : \mathbf{P}_{pr} \rightarrow \mathbf{K}_j \qquad (6.2)$$

where: $\mathbf{P}_{pr}$ – set of designed objects.

Decision-making function

Decisions referring to quality of objects that comprise the scope of individual actions constitute an indispensable component of any human activity. The decision-making function pertains to the elements of the decision-making model. In the decision-making process, qualitative categories have the function of **decision-making variables**, **limitations** and **selection criteria**. The decision-making function is closely linked with operation and evaluation principle (Items 4.4 and 5.9). Therefore, the selection criterion is determined based on the category of evaluated quality. The essence of the decision-making function is expressed in the proper assignment of qualitative categories to decision-making variables, limitations and selection criteria in the decision-making model. The decision-making function F_{dec} may be recorded as follows:

$$F_{dec} : \mathbf{K}_{dec} \rightarrow \mathbf{K}_j \tag{6.3}$$

where: $\mathbf{K}_{dec}$ – set of decision-making categories (decision-making variables, limitations and selection criteria).

Optimisation function

The decision-making processes are usually aimed at making optimum decisions (Item 5.10). Therefore, it is necessary to develop and work out an optimisation model. The optimisation function consists in proper assignment of qualitative categories to elements of model, i.e. optimised variables, limitations and optimisation criteria. The application is related to the operation and the principle of optimisation of object quality (Item 4.5 and 5.10). The general notation of the optimisation function is similar to that of the decision-making function, and the set of decision-making categories is replaced with the set of optimisation categories.

Stimulating and motivating function

In operating systems there occurs the need to use stimulating (stimulus-based) influence on subjects[1] in order to shape the desired motivation system and then the adequate response to stimuli. In the performance of the stimulating and motivating function, it is important to properly select stimulants adequate to subjects, goals and situational variables. Management in operating systems, apart from being oriented on the achievement of **qualitative goals**, is also characterised by the use of qualitative stimuli which influence, respectively, the quality of motives which in turn assure behaviours of stimulated subjects adequate to objectives. These responses occur as the quality of work processes and work results. The chain of causal connections in the stimulation process is as follows:

Qualitative objectives → Quality of stimuli → Quality of motives
→ Quality of work processes → Quality of work results.

The stimulating and motivating function F_{sm} is expressed as the proper assignment of qualitative categories to stimuli and motives related to the given action. The general notation of this function is as follows:

$$F_{sm} : \mathbf{C}_s \rightarrow \mathbf{K}_j \tag{6.4}$$

where: $\mathbf{C}_s$ – set of stimuli and motives.

[1] Subjects may comprise people, social groups, organisational units and organisations.

6.2. Language and the semantic function of qualitology

Thinking processes are externalised in the form of language which is a system of signs [2] equipped with semantic properties. Language enables the **creation**, **storage**, **communication** and **evoking**, in the minds of people[3], abstract objects, including abstract objects that are the images of material objects. Thanks to that, relations between humans and reality may be identified and resources of information and knowledge of reality may be created. The most important type of simple signs used in human communication are verbal signs: parts of speech, parts of sentence, words, names, terms etc. of which complex signs are made up: phrases, sentences and more complicated contents. Elementary linguistic signs include letters, digits, punctuation marks, graphic signs etc.

In the creation of language and communication processes, semantic problems related to the contents of verbal signs are of particular importance, as well as pragmatic problems, regarding the relation between verbal signs and the corresponding notions evoked in subjects using these signs. One of the major conditions for communication is assuming, by the sender and receiver of the message, an explicit semantic convention, consisting in the normalisation of semantic fields of signs used in a language.

The possibilities of generating and storing in memory the comprehensively and structurally perceived images of objects, associated explicitly with specific linguistic signs, as well as the capacity to carry out conscious mental operations using these images, make up the **primary mechanism of reality modelling** and **creative work** of humans.

The capacity to perceive reality, building images, observations and ideas, as well as the need to communicate lead to the generation of **individual names**, assigned to individual single objects, and **general names**, assigned to sets, classes, types, kinds or groups of similar objects[4]. This means that an individual name has one and only one designatum, and a general name

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[2] "A sign in the strict sense is a noticeable scheme of things or a phenomenon caused by someone due to the fact that certain principles, established explicitly or formed by custom, require the certain thoughts to be associated with said scheme of things or mental phenomenon carrying a specific content" [70, p. 12].

[3] In qualitological approach, the linguistic signs equipped with specific contents become specific abstract objects that make up the given language.

[4] "Name is a word or an expression which may function as a subject or predicative of a nominal predicate in a sentence" [70, p. 25].Name may be simple (one-word) or complex (multi-word), as well as specific (indicating a thing or subject) and abstract (meaning a common feature, event, state of things or relationship between objects) [70, pp. 25-26].

has at least two designata[5]. Grounds for the creation of a general name for a specific set of similar objects are provided by **common quality $\mathbf{J}_w$,** which determines simultaneously the **notion** (semantic field) of the name: general name $\leftrightarrow\mathbf{J}_w$. Thus, each **general name is a sign**, **which, through the semantic function evokes a notion which is common quality for a set of objects**.

The set of all objects that are the designata of the general name is a full one, and concurrently the **range** (scope) of this name. A condition sufficient to assign a given object to the range of a general name requires that common quality ($\mathbf{J}_w$), belonging to all designata of the given name, is included in the quality of this object ($\mathbf{J}_w\subset\mathbf{J}^p$). On the other hand, if $\mathbf{J}_w\not\subset\mathbf{J}^p$, then the object is not a designatum of the name, which means, concurrently, that it does not belong to the set of objects labelled with this name.

When determining the range of the general name, the **problem of fuzziness** of the range may occur (problem of vagueness [69, pp. 34-36]). This problem occurs when common quality designated with a specific general name is a fuzzy quality (the general name does not have explicit content [70, p. 36]) or if the membership function μ_J has been applied when qualifying objects to the range of the general name. The phenomenon of fuzziness of the range of general names occurs commonly in colloquial language and, to a considerable extent, in many scientific disciplines, which impairs the effectiveness of communication.

In order to linguistically distinguish objects denoted by given general name, a set of **individual names** should be created, based on the qualities of individual objects in the given set. A rule in determining a notion assigned to an individual name is to refer to a specific general name (identifying common quality $\mathbf{J}_w$), within the range of which the given object is and to determine **individual quality $\mathbf{J}_i$** as a complement of common quality to this object's quality $\mathbf{J}^p$. The sum of common quality and individual quality is the object's quality, and, at the same time, the notion (content), identified by given individual name: individual name of object $\rightarrow\mathbf{J}_w\cup\mathbf{J}_i=\mathbf{J}^p$. Thus, each individual name is a sign, which, through the semantic function evokes a notion which is the quality of a specific object. By assumption, the range of an individual name is a set with one element and the range of a general name – set of at least two elements.

The operation of isolating objects from reality is relative in nature. This means that the specific object is regarded as individual and labelled with an

[5] Designatum of a name is an object for which the specific name is a verbal sign [70, p. 27] Therefore, the name has a function of identifier of an object or a class of objects in mental processes.

individual name or is regarded as a set of similar objects and labelled with a general name, depending on situation and the purpose of such operation. For instance, if the isolated object comprises a set of objects, then potential other similar objects will be other sets of objects demonstrating similarity. Until at least one other similar object or set of objects is found, the name of the given object or set of objects will be an individual one. After finding such an object or a set of objects, general and individual names should be created.

Objective possibilities, determined mainly by the infinity of the set of objects comprising reality and the need to rationalise any language as a communication tool result in the fact that they are dominated by general names (e.g., thing, abstraction, atom, design, product, goods, car, process, system, river, feature, city, action, swimming, star), and only relatively scarce set of names contains individual names which function as identifiers of single objects quality in absolute sense (e.g., Poland, Cracow, the Vistula, the Sun, the Tatras, Adam Mickiewicz, the January Uprising, a specimen of desk bearing a specific stock number, the Eiffel Tower). The widespread absence of individual names in language results in the fact that the general names must be most frequently used to identify the quality of specific, individual objects. This may cause error consisting in equating the quality of a specific object with a common quality determined by the general name used, the range of which only covers the given object.

The suggested solutions to semantic problems allow the formulation of a methodological principle of studying objects' quality, consisting in the fact that while determining the quality of an object that is a designatum of a general name, one should check whether the object is eligible for common quality identified by this name, and then determine the complement to the common quality. Such a solution is also aimed at **qualitological standardisation of terminology**, consisting in assigning, in an unambiguous manner, appropriate common qualities of specific sets of objects or qualities of specific objects in these sets to general or individual terms of a given language. This may be achieved using the **semantic function of quality** F_s, the general notation of which is as follows:

$$F_s : \mathbf{Z}_s \to \mathbf{K}_j \tag{6.5}$$

where $\mathbf{Z}_s$ – set of linguistic signs.

In colloquial language, semantic problems are solved on the ground of long-standing tradition and practice, supported by individual intuition in the understanding and use of language. In academic language, the degree of semantic standardisation is much higher, although it usually pertains only to key terms of the given scientific discipline. In many scientific disciplines there is disagreement as regards the definitions of these terms, which results in an unfavourable phenomenon of **individualisation of notions**. Concurrently, three phenomena occur, unfavourable in respect of language efficiency.

The first phenomenon consists in the introduction of new names of terms, used only in a given scientific discipline, which results in **esotericism** of language, **isolation** of discipline and **weakening of system coherence** with other academic disciplines. The second phenomenon comes down to assigning different notions to same names and terms (assignment of different qualities of various objects to a specific individual name or different common qualities of different sets of objects to a given general name) which **decreases the efficiency of communication processes**. The third phenomenon occurs when the same notions (qualities) are assigned to many names or terms, which leads to the **excess of form** of language over its informative function and, also, deteriorates the efficiency of communication processes. The study of the efficiency of communication process consists in the analysis of effectiveness expressed by the level of **qualitative similarity** of information received to information sent and on the analysis of efficiency measured by the relation of effects to expenditures related to the process.

The aforementioned shortcomings and intensive development of languages in relation to the dynamic development and emergence of new scientific disciplines at absence of explicit, commonly known and acceptable semantic norms result in the fact that in academic, as well as in colloquial, languages terms with vague (fuzzy, approximate) and individual semantic fields are used. The occurrence of this highly unfavourable phenomenon causes, i.a., that the sets of designata of such terms are **individualised** and **fuzzy sets**. One of the methods to improve language and efficiency of communication should be the application of qualitological semantic function.

6.3. Classification function of qualitology in systematics of objects

Reality, discovered comprehensively and more in-depth, is an endless source of objects that undergo continuous qualitative changes. The purpose of using the classification function of qualitology is simplification, organisation and systematisation of reality. It is rooted in the **common phenomenon of qualitative similarity and diversity of objects** (Item 4.3). A vital decision in any classification process is the selection of one (single-criterion classification) or many (multicriterial classification) classification criteria. In qualitological approach, qualitative categories, mainly features and states thereof should be assumed as criteria of object classification. On the other hand, the classification itself should meet the known requirements of completeness and separability[6].

According to separability requirements, the fuzzy sets theory is not applicable in classification. The exclusion of the requirement of separability enables the use of **fuzzy common quality** for the division and organisation of a specific set of objects. The consequence of such an approach are fuzzy subsets of objects.

The classification process and results may be characterised by features of width and depth. **Feature of width** is determined based on the size of the set of objects that is being classified and the number of classes at individual classification levels. **Feature of depth** is determined based on the number of criteria and classification levels. Both these features can affect the size of the set of all classes that objects of a specific set were assigned to.

The depth of classifications based on the analysis of object similarity depends on the size of sets of common qualitative categories, assumed as criteria of grouping of similar objects. The simplest and yielding the most general result is the classification based on one dichotomous feature (e.g., feature of gender dividing people into two classes: women and men). The gradual increase in the number of jointly applied criteria and their states results in classification of growing multidimensional character and number of class, in line with the following principle - **there are as many levels of classification as there are criteria applied and as many classes at a given level as there are states of a given criterion.** If all classified objects are assigned to quality that distinguishes them from all the other objects, there is such a level of classification at which classes are comprised of a single element.

The lower rate of changes in time and the higher information capacity of the contents of objects' features in relation to greater rate of changes and lower information capacity of contents of states of features results in more stable and more durable belonging of features and states of features to objects. This regularity has an analogical impact on the stability and durability of classification results based on features or states of features. Undoubtedly, classifications based on common states of object features are less stable and durable than those based on common features. However, regardless of the above regularities in the analysis of similarities and classification of objects, in any case one should consider the changeability of quality of classified objects in the function of time. Changes in the criteria of classification and

[6] The operation of organising and systematising reality which does not adhere to these requirements may be referred to as typology.

qualitative transformations cause specific changes in the results of classification of these objects.

The classification function may be resolved into two functions. The first one, F_k, consists in the adequate assignment of qualitative categories to individual classes in order to determine **qualitative common categories** as a basis for grouping similar objects into classes. The other function, F_p, consists in adequate assignment of adequate classes of a given classification to individual objects in a given set of objects. The assignment of object classes consists in finding such classes, whose sets of qualitative categories are included, respectively, in the sets of qualitative categories of individual objects. If a set of qualitative categories of an object does not contain a set of qualitative categories of any of the classes, then the object is beyond the scope of a given classification. In general notation, the above functions are as follows:

$$F_k : \mathbf{K}_l \rightarrow \mathbf{K}_j \text{ and } F_p : \mathbf{P} \rightarrow \mathbf{K}_l \quad (6.6)$$

where: $\mathbf{K}_l$ – set of classes in a given classification.

The result of application of the classification function occurs in general as a multi-level and hierarchically organised scheme of classes, to which objects were qualified based on qualitative similarity. This similarity is standardised, graded and expressed in common qualitative categories (common feature, common state of feature, common intensity of feature, common quality, common state of quality etc.). The very operation of qualifying objects to specific classes consists in finding that qualitative data of common categories corresponding to these classes are included in the qualities of individual classified objects. In order to facilitate communication in the area of classification, individual classes may be assigned specific names. Except for one-element classes, these names will be general, with designata including objects classified to individual classes.

6.4. Category of the quality of human life

The notion of life refers to organisms and stresses the **process** and **comprehensive** approach to their existence in time. The lives of organisms may be considered in reference to individuals, groups, species etc., using individual and statistical descriptions. For obvious reasons, particular interest is expressed in human life. The lives of humans contain fully comprehensive description of human beings in the process of **qualitative changes** they undergo in the function of time. This process is identifying as ontogenesis or philogenesis. There should be no controversy about the thesis that life is a category assuring the fullest possible approach to the essence of man, which is important for the cognitive, as well as creative and causative processes handled by man.

A category of quality may be assigned to the life of humans, analogically as to any other component of reality. The possibility of, or even the need for this operation results from the function of qualitative categories in epistemological and axiological consideration of reality. Therefore, in general, the notion of quality of life emerges, in particular – the notion of the quality of human life.

The category of quality of life is present in the publications of Romuald Kolman. Like no one else, he sees the need and utility of the application of this category in business and social activities. He also proposes specific methodological solutions to define and interpret the quality of life [29, pp. 112-141]. These solutions correspond to the practical trend, dominating the quality engineering, which stresses the evaluating approach to quality.

In line with the terminological convention adopted in this book, the proposed description of the quality of human life is as follows:

Description 6.1. **The quality of human life is the set of features belonging to the process of existence of a person or a set of persons.**

While extending the interpretation of the above description of the quality of life, the following statements should be noted:

- quality of human life applies to anyone and then it has an individual dimension (analytical) and to a specific set of persons and then it has a general dimension (statistical, synthetic),
- quality of life uses a process approach and may cover the entirety of the process or any fragment thereof (phase, stage etc.),
- it is possible to identify the quality of life in a descriptive sense (cognitive, epistemological) and evaluating (assessing, axiological),
- the second level of accuracy of the description of the quality of life is assured by the trajectory of the state of the quality of life determined based on the set of states of features.

Figure 6.2 presents a brief diagram of examining the quality of life taking into account the determining factors.

Even such a simplified presentation of the quality of life as presented in Figure 6.2 demonstrates extraordinary complexity and difficulty of the problem of comprehensive consideration, examination and determination of this quality. It may be believed that the **quality evaluation operation** will be particularly complicated in methodological and practical terms. One of the reasons for this complication is the possibility of and need for subjective and objectivised evaluation. People and social groups cannot be denied the right to subjective evaluation and projection of their quality of life nor the attempts to develop scientifically grounded models of this quality that serve as reference in objectivised evaluation processes should be abandoned. Such an approach will result in an interesting, in cognitive and causative terms, problem of discrepancy of models and subjective and objectivised results of the evaluation of the quality of life[7].

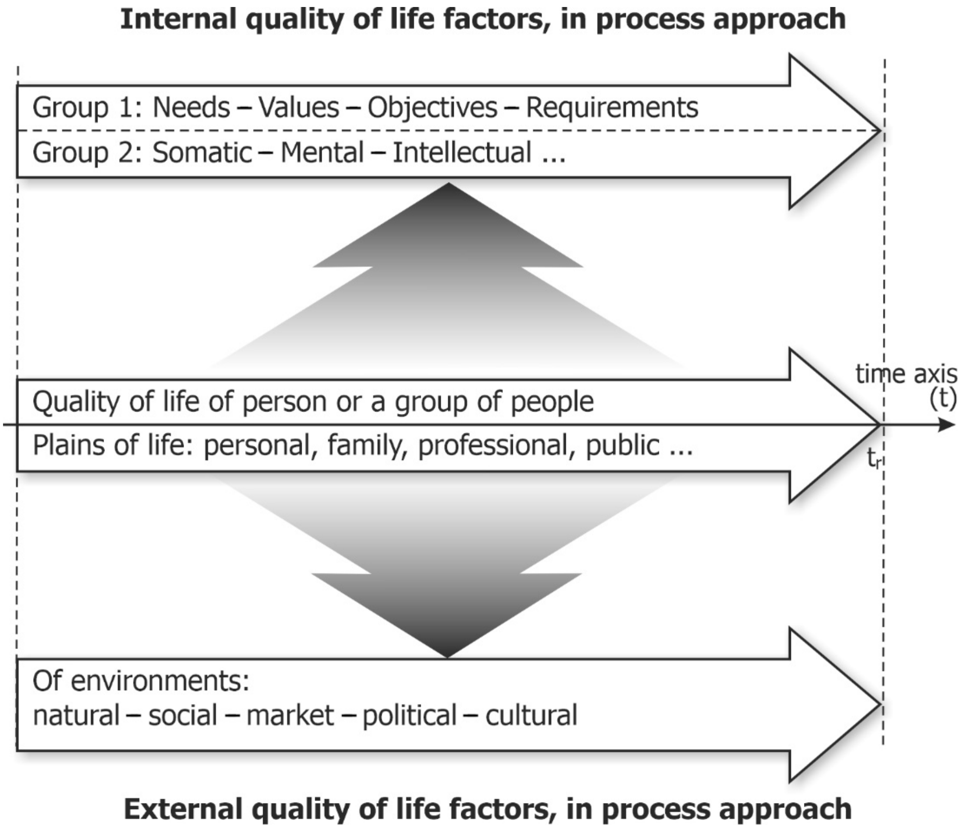

Fig. 6.2. Quality of human life

Despite considerable difficulties in solving the above problems, many premises indicate a huge significance of the quality of life category as the

[7] The issue of evaluation of the quality of life is strongly connected with much diverse systems of values, worldviews, ideologies, culture, politics, social relations and other manifestations of human activity.Absence of harmony in the application of the objectivised and subjective models of the quality of life may be at times manifested in totalitarian forms of organisation of societies.

primary reference for consideration of anything that relates to human beings. Therefore, one may formulate a paradigm regarding the **primacy of the quality of life** over the entire human activity, oriented on the cognition and deliberate shaping of reality in the process of satisfying human needs.

6.5. Management quality category

In the activities of any organisations, management carries strategic importance and should be a particular object of research in qualitology. A vital complement of qualitological issues in management is, apart from quality management, the quality of management (Item 4.6). The scope of consideration of the quality of management may change: from covering all management functions and entire organisation (comprehensive approach) to considering only one management function and one component of organisation (partial approach). Management in organisations occurs here as a complex object, the quality of which should be designed, implemented, studied, diagnosed, analysed, controlled, evaluated, verified, improved etc.[8]

The extraordinary complexity and difficulties in solving problems related to the quality of management result, inter alia, from the complexity of management processes, high dynamics and occurrence of heuristic processes and multi-dimensional approach to quality, as well as difficulties in the application of the principles of quality-based approach, in particular the principles of evaluation, optimisation, synergy and complexity. Such a state of affairs is probably one of the main reasons for explicit absence of the topic of quality of management in qualitological literature.

The quality of management issues is implicitly present in the deliberations on quality management, which is stressed by, *inter alia*, the **integrativeness** of both qualitological aspects of management. For instance, the following eight principles of management contained in standard PN-EN ISO 9004:2001 – Quality management systems, guidelines for the improvement of operation: (1) customer orientation, (2) leadership, (3) involvement of members of the organisation, (4) process approach, (5) system approach, (6) ongoing improvement, (7) making decisions based on adequate information, (8) mutual, favourable relations with vendors may be partially included in the quality of management. Also, the quality of the entire set of quality management instruments co-determines the quality of management.

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[8] The high priority of the quality of management results from the role of management for the existence, development, results of operation and success of any organisation.As early as in the 1950s J.M.Juran and W.E.Deming claimed that 85% of errors occurring in an organisation are caused errors in management and only 15% – from errors in execution [49, p. 581].

Another example of deliberations on the quality of management is the fourteen principles of Deming [17, pp. 94-95].

A methodological tip in the process of studying and shaping the quality of management is the treatment of management as a specific class of action and using universal components and the general structure of operation. These components include: subject, tool, material, objective and result of action. Therefore, the quality of management as action will be conjunctively determined by:

- **quality of executive staff** in an organisation, determined by personality, knowledge, skills, creativity, and management aptitude,
- **quality of management tools**, determined by technique and methodology applied in the work of managers,
- **quality of materials**, which occurs mainly as the quality of input information in management information and decision-making processes,
- **quality of objective and result**, determined based on planned and actual results of management work, taking on the form of decisions made, concepts, plans, programmes, forecasts, designs, systems, methods, technologies, models, results achieved etc.

In the determination and structuralisation of the quality of management, a management functions tree is useful. Such an approach enables the determination of quality of any component at any level of expansion of the function tree. At first level of expansion, it will be the quality of planning, organising, leading, and controlling an organisation’s operation. The shaping of the quality of management should be manifested by the proper **design quality of management**, and then in its effective implementation, application and ongoing improvement.

CONCLUSION

This book presents the author's concept of the overview of qualitology while assuming that the existing scientific quality-related achievements justify the attempt to assign it features of a knowledge system in order to speed up further development and possible isolation in the form of a scientific discipline. Common presence and significance of the category of quality in intellectual and practical activities of man confirm the rightness of taking up this scientific task.

The formulated basic, and partly solved, academic problems include: the formulation of the subject-matter of qualitology, development of terminological foundations and methodology of approach as well as qualitative modelling. The solutions to these problems proposed in the overview are based on defining the quality category on the grounds of set theory and on the rationale that it is the basic epistemological category, as well as on developing six basic qualitative operations and formulating eleven principles of quality-based approach as a new paradigm in the study and shaping of reality by man.

The value of the developed overview of qualitology lies not only in the proposed solutions and legitimate propositions, but perhaps most of all in the formulated problems, theses and hypotheses which constitute a scientific proposal for interested researchers. Also, to that end the directions for further research resulting from the developed overview of qualitology are presented below.

Directions for research resulting from the subject-matter and division of qualitology

Potential directions of research resulting from the proposed subject-matter of qualitology should aim at the development of theoretical concepts regarding: expansion, unification and organisation of terminology, further expansion and structuralisation of the scope of reality, research perspective, objectives and research tools. One of the basic directions of research is further systemisation and synthesis of huge achievements regarding quality, dispersed across many scientific disciplines. Further directions of research pertain to the problem of the comprehensiveness of research perspective through search and to adaptation or **creation of new theories of formal modelling**, useful in qualitative modelling. Equally relevant direction in the development of qualitology should be the expansion of theoretical grounds for qualitative approach as a new paradigm in cognitive and engineering activities. All principles of quality-based approach need to be expanded. Also, the search for new applications of qualitology is an interesting area of research.

The complexity of the subject-matter and rich scientific achievements justify the need for division of the science of quality. To date, the problem has not been sufficiently solved. It should be assumed that many concepts for structuralisation of qualitology are possible. However, each of them should meet the requirements of completeness and coherence of the science of quality as well as adequacy to the existing, anticipated and desired directions for the development of this area of knowledge. The division of qualitology into parts proposed herein concurrently determines the directions of research works aimed at the expansion, elaboration, and development of problem specification as well as creation of instruments that would help discover a methodological solution. The **general theory of quality** requires particular interest and further expansion.

Directions of the development of qualitology defined by three research perspectives

Under the descriptive research perspective, a theory should be developed, covering the methodology of building quality models (mappings, images) of objects. To perform these tasks, the development of the methodology of defining and systemisation of object quality is necessary. Inter alia, the research of possibilities to apply metrology in quantitative determination of quality is needed. In pursuit of cognitive and practical objectives, the systemic and holistic modelling of object quality is of considerable importance.

Under the comparative research perspective of qualitology a theory should be developed, covering the methodology of qualitative comparative analyses taking into consideration the non-evaluated and evaluated quality. The qualitative comparative analysis occurs, i.a., as a potential research direction related to solving the problem of image or speech recognition etc. The thing is to identify objects based on recorded mappings (qualitative models), which occurs in the military, forensics, medicine etc. An interesting research issue covers qualitative transformations occurring in the function of time and capable of changing the results of classification operations.

Within the third, axiological research perspective of qualitology, a theory should be developed, covering the methodology of studying the relation between the quality of objects and man, including the theory of evaluation and optimisation of quality. Another interesting direction of research determines **praxeological**, **economic** and **psychological evaluation of quality**. Another important, in practical and cognitive aspects, research direction is one regarding the construction of formalised optimisation models of artificial objects quality, adequate to various decision-making situations [37].

Due to the needs of economic practice, it may be believed that evaluation and optimisation of artificial objects quality are the priority directions of qualitology development. In this respect complex and difficult issues may be encountered: research of needs, goals and requirements; selection of evaluation and optimisation criteria; multiple criteria; objectivity and subjectivity of approaches; comparability and relativity of evaluation and optimisation results; evaluation functions; optimisation models; quality models and many more.

Directions of the development of qualitology defined by qualitative approach principles

Within the presented overview of qualitology, eleven principles of a new paradigm, referred to as the qualitative approach, were presented. The resulting directions of research should aim at the development of theoretical grounds for this approach and the application of each principle and at creation of methodology of solving engineering problems in this respect. A particularly interesting topic, in cognitive terms, is the application of the evaluation, optimisation, synergy, kinetics, economics and standardisation principles.

The synthetic directions of further research of the development of qualitology indicated above surely do not exhaust all possibilities in this area. They also require more thorough decomposition and fuller identification. These directions are a proposal of continuation of the author’s concept of qualitology presented in this book. If studied by other researchers, they offer an opportunity of many benefits, both in scientific and practical terms.

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