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DEFINITION IN SCIENTIFIC AND TECHNICAL DISCOURSE

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Abstract*: The paper deals with the notion of definition as one of the rhetorical functions used by writers of scientific and technical English to provide information about a given concept or object. Specifically, definition is an explanation of a concept or objects that distinguishes this concept or object from all others. It is one of the most important and frequently employed rhetorical functions in English for Science and Technology discourse. At the instructional level it is found frequently in association with physical concepts, e.g. physical objects. When dealing with objects, definition is the process of stating what a given object is, either by describing its physical structure, its use or purpose, the way in which it functions, or a combination of two or all of them. It is an essential part of organized thinking and, thus, it is basic to scientific and technical discourse. A definition locates its subject in a class and then proceeds to point out the characteristics that make it differ from other items in that class and that, therefore, allow it to be assigned to a subclass. This process is a special variant of the process of classification. A definition simply sets its subject in a limited scheme of classification. The process of definition is a natural way the mind works. The language of definition should be as logically precise as possible. The purpose of a definition is to limit the meaning of a word which stands for an object in an acceptable way. For this purpose metaphorical language is not used in scientific and technical discourse, because the essence of metaphor is not to limit meaning but to extend meaning by developing new and complex ranges implicit in the literal base. Definitions are expressed either explicitly or implicitly in scientific and technical discourse. Explicit definition is that type of definition which makes clear through phrasing that a particular concept is being defined. Implicit definition presents information also, but it does not present it in defining terms. The paper investigates how definitions are made in lectures with a view to the development of a more appropriate pedagogy for teaching the comprehension of this important language function.*

Key words: definition, scientific and technical discourse, rhetorical function

1. INTRODUCTION

Definition is one of the most important and frequently employed rhetorical functions in EST (English for Science and Technology) discourse. At the instructional level it is found frequently in association with physical concepts, e.g. physical objects. When dealing with objects, definition is the process of stating what a given object is, either by describing its physical structure, its use or purpose, the way in which it functions, or a combination of two or all of them. It is an essential part of organized thinking and, thus, it is basic to scientific and technical discourse (Swales, 2004).
Definition locates its subject in a class and then proceeds to point out the characteristics that make it differ from other items in that class, and therefore, allow it to be assigned to a subclass. This process is a special variant of the process of classification. A definition simply sets its subject in a limited scheme of classification.
The process of definition is a natural way the mind works. The language of definition should be as logically precise as possible. The purpose of a definition is to limit the meaning of a word which stands for an object in an acceptable way. For this purpose metaphorical language is not used in scientific and technical discourse, because the main function of metaphor is to extend meaning by developing new and complex ranges implicit in the literal base. Definitions are expressed either implicitly or explicitly in scientific and technical discourse.

2. IMPLICIT DEFINITION

An implicit definition is usually found in a paragraph of information which contains particular kinds of information often mixed with other kinds of information, that are given by a definition, usually formal or sometimes semi-formal. In a paragraph of implicit definition the defining information is scattered through or mixed with other kinds of information and should be abstracted from the paragraph and put together as a definition by the reader. It is only possible for the reader to do this when he knows what kinds of

information make up a definition, i.e., the term being defined, the class to which the term belongs, and the differences which distinguish the term from all other terms of the same class.

Example 1. Print Media

Topical surveys on the significance and use of print media prove that the need for print media is growing worldwide. This is indicated by the fact that at the end of the millennium Time Magazine acknowledged the socio-cultural significance of the invention and utilization of book printing and elected Johannes Gutenberg's work as the most crucial event of the millennium. It is true that the age of electronic media has started; however printed information is and remains omnipresent. Depending on level of education, income, and household type, between US$ 20 and US$ 55 per month and household were spent in Germany in 1997 on books, brochures, magazines, and newspapers. The market for print products offers more variety than ever before. Usually, printed products are categorized into commercial printing and periodicals. This classification differentiates printed matter with regard to its frequency of publication. Since the production process also depends largely on these basic conditions, print shops usually specialize in one or the other market segment. Commercial printing refers to print products that are produced occasionally (e.g., catalogues, brochures, leaflets, business cards, etc.). Periodicals are printed matter that appears periodically (e.g., newspapers, journals, magazines). Publishing houses and companies are the typical clients for periodicals printing. Another way of categorizing printed products is by splitting them into special product groups (Kipphan, 2001).

Implicit defining information is *buried* in a paragraph whose primary purpose is not to define but something else. The specific rhetorical function of this paragraph is that of *description*, in this case a *function description* of a print media. Buried in the information supporting this rhetorical function of description is information which can be presented in the form of an explicit formal definition, if extracted and reordered to produce an explicit formal definition.
Implicit definitions are found frequently in English for Science and Technology. They are more frequently found in technical books or articles written for more advanced students, engineers or experts in particular fields. They are not explicitly stated but given by implication, thus, they make use of context and, at times, the reader's previous knowledge, to make clear what the given concept is.
Since definitions are often given by implication in English for Science and Technology, the reader should learn to recognize these definitions and to be able to frame the information in defining terms, which means to have a more formal, clear, and precise grasp of the information presented.

3. EXPLICIT DEFINITION

Explicit definition can be classified into three broad types on the basis of how much and what kinds of information each type gives the reader and how precise that information is. These three types are: formal definition, semi-formal definition and non-formal definition. Besides, definition by stipulation and expanded definition are also explicit definitions.

3.1. Formal definition

It provides maximum information at the highest possible level of precision. This is the traditional type of definition and it consists of three parts:

- the term or concept being defined (the species);
- the family or class to which the term belongs (the genus),
- the differences between the term being defined and all other members of the class (differentia). It is usually found in a single sentence.

For example, in the sentence

> *Engineering is the process of harnessing or directing the forces and materials of nature for the use and convenience of man.*

The elements of a formal definition can be seen as an equation:

The term being defined	=	*Class*	+	*Differences defined*
Engineering		is the process		of harnessing or directing the forces and materials of nature for the use and convenience of man.

There are several methods of defining. Most commonly they are:

- definition by purpose,
- definition by operation,
- definition by example,
- definition by use or function,
- definition by physical description, or
- definition by a combination of two or more methods

The kind of information given in the differences depends on what method of defining the writer chooses. These different methods of defining can be seen in the following examples.

Example 2. Formal definition in EST by purpose

> *Guillotine is a machine used for trimming stacks of paper.*

The term being defined is *guillotine.* It is a member of a class (group) of things called *electronic devices,* and it differs from other electronic devices in its purpose which is to trim stacks of paper.
The kind of difference here is *purpose;* thus, the method of defining is definition by purpose.

Example 3. Formal definition in EST by physical description

> *Paper guillotine consists of a base at least 1 foot (30 cm) long on each side for small work with a long, curved steel blade, often referred to as a knife, which is attached to the base at the top right-hand corner.*

In this case the definition is by physical description because the writer names the parts which compose a guillotine.

Example 4. Formal definition in EST by operation

> *When the knife of a guillotine or paper cutter is pulled down to cut paper, the action resembles that of a pair of scissors, only instead of two knives moving against each other, one is stationary.*

In this case the definition is by operation description because the writer explains the operational procedure.

3.2. Semi-formal Definition

A semi-formal definition is the most frequently used type of explicit definition. It contains almost as much information as a formal definition except that the class is left out (Swales, 2011). The reasons why the class is left out are usually:

- because the writer feels that the class will be obvious to the reader, or
- because the class is so large that it is meaningless, so that he can present the definition in formal form. Examples of classes of this type are *science, device, process, word,* etc.

Example 5. A ceramic is a combination of one or more metals with a non-metallic element, usually oxygen. (A semi-formal definition in EST by physical description)

In the above example the class: *chemical compound* is not stated because obviously the writer assumes that this is information the reader possesses. Instead he gives the reader information about the physical characteristics of the term being defined, i.e., what a *ceramic* is made of. Method of defining here is definition by physical description.

Semi-formal definitions of the formal definition given in Examples 2, 3, and 4 would read:

Example 6. Guillotine is used for trimming stacks of paper.

Example 7. Paper guillotine consists of a base, and curved steel blade.

Example 8. When the knife of a guillotine or paper cutter is pulled down to cut paper, the action resembles that of a pair of scissors, but one of them is stationary.

3.3. Non-formal Definition

The most common types of non-formal definition are those definitions given by synonym and antonym.

3.3.1. Definition by Synonym

It simply presents a word or short phrase which is an approximate equivalent to the term being defined. Synonyms are often presented as appositives, or in parentheses (Miller, 1984).

Example 9. The printing areas of the printing plate are oleophilic or ink-accepting and water-repellent or hydrophobic.

3.3.2. Definition by Antonym

Definition by antonym is the second most common type of non-formal definition. In this type of definition the writer gives a word that means the opposite of the word being defined. In such cases the author is usually assuming that the antonym is a word the reader will understand, and therefore, he can use it to learn the meaning of the word being defined (Hayot, 2014).

Example 10. Hydrophilic is the opposite of oleophilic.

Closer explanation of last definition:

Hydrophilic: A quality of certain papers, components of paper or non-image areas of lithographic plates that cause them to absorb and/or be receptive to water. In offset lithography, a hydrophilic substance is likely to be receptive to water and fountain solutions and repellent to oils and oil-based inks.

Oleophilic: A quality of certain papers, components of paper, or the image areas of lithographic printing plates that causes them to have an affinity for oils and oil-based inks. Oleophilic substances are likely to repel water. Oleophilic substances are also called lipophilic and are considered hydrophobic.

3.4. Definition by Stipulation

It is a special type of explicit definition in which a particular term has a particular meaning in a given situation, but does not necessarily have that meaning in other situations. There are two types of stipulation: mathematical stipulation and specifying stipulation.

3.4.1. Mathematical Stipulation

Mathematics uses a great deal of stipulation when specifying the meaning of the symbols in an equation or formula. Mathematical definitions are a special type as the *language* of mathematics is universal, i.e. we are dealing with a set of symbols universal in form (Harmon & Reidy, 2002).

Example 11. Let A and B be any two sets. A mapping of A into B is an operation Ø which assigns to each element a of A a well determined element of B which we denote Ø (a) and call the image of a under Ø.

In the above stipulate definition the term *mapping* is being defined. It belongs to the class "*an operation Ø*" and sum of differences are "*which assigns to each element a of A …*"

Example 12. Printing is a reproduction process in which printing ink is applied to a printing substrate by pressure, in order to transmit information (images, graphics, text) in a repeatable form using an image-carrying medium (e.g., a printing plate). (*Definition by mathematical stipulation in graphic engineering)*

Thus, the pressure (P) used in printing presses is defined by the Equation 1:

$$P=dF/dA \quad (1)$$

where **dF** denotes the force (in Newtons), and **dA** the surface (in sq meters).

In the above example the definition of *pressure* is given by equation and then the meaning of the symbols in this equation is specified.

3.4.2. Specifying Stipulation

This kind of stipulate definition is used very frequently by scientists when they coin names for new discoveries or assign new terms or apply old terms in new ways to activities, processes, or objects resulting from their research. Thus, reports and papers contain the following expression:

When the term X is used in this paper, it means so and so.

Example 13. Definition by specifying stipulation

a) In information theory "*entropy*" means "*information" or "freedom of choice of an information source".*

b) "Failures due to excessive deformation are those which produce excessive deflection, and depend primarily upon relative module of elasticity of the material. *Here in*, resistance to over deformation is termed *stiffness of the member."*

c) "In this text, a measure of the ability of a member to resist overstressing is referred to as *strength of the member* and stress always means *force per unit area*."

In the above quotations the writer is stipulating the meaning of "*entropy*", "*resistance to over deformation*" and "*a measure of the ability of a member to resist overstressing*" and "*stress*". All these terms and phrases have particular meaning in this given situations, but they have different meanings in other situations, e.g., in other fields of science.
All the above mentioned explicit definitions (formal, semi-formal, non-formal, and definition by stipulation) are given in one single sentence. But very often one single sentence is not enough to explain a new concept or object and the reader needs more information.

3.5. Expanded Definition

One sentence long formal definition cannot give enough information to satisfy the reader's understanding. If an idea or a complex object is being explained, it is necessary to develop the definition further by making use of examples, comparisons, contrasts, cause and effect, time order, space order and other explanatory devices. An expanded definition has its core in the form of a definition. How it is developed depends on the nature of the concept or term being defined and the writer's own approach to it. Most expanded definitions are fairly short, usually not longer than a paragraph, but some may require an essay of several thousand words or even a volume.
The most common ways in which definitions are expanded are classification, description (all types), exemplification, illustration, explication, and operation.

3.5.1. Definition Expanded by Classification

Throughout recorded history creative men as well as scientists, have first given names to something new and then made definitions of the things they have named, so others could understand. Likewise, the concept of classification has been developed because the things surrounding us are so numerous, that humans needed to see them in a perspective small enough for the human minds to grasp. Thus, they have learned to relate things with some elements in common, and think about them in terms of their classes, their common factors, which let them think more clearly. In other words, through classification, man has organized the world around him. That is why definitions are most commonly developed or expanded by classification.

Example 14. The printing press is the equipment with which the printing process is performed. Processing press includes the following areas of function: materials processing (e. g., inking, printing, substrate transportation), drive (motors and transmission elements), control system (e. g., sensors, actuators, and control processors), support and covering area (frame, bearings, guides, guards).

The core generalization is the formal definition stated at the beginning of the paragraph. This formal definition is then expanded by classification in which the other members of the class are given. Then each member of the class is physically described.

3.5.2. Definition Expanded by Description

In order to classify things, man first had to observe how things were similar or different in their physical natures and in the way they worked. Thus, he learned to describe. It should be noted that definition, classification and description (which together add up to explanation) are all essential to scientific thinking and thus, they are found most commonly in scientific writing (Gross, 2006).

Example 15. We might define production as the way material is transformed by factory methods into things wanted by society. For example, the sales orders are taken and the raw material is ordered. The raw material is received and manufacturing orders are fed to the plant at a rate and sequence at which the plant can handle them. Now the raw material is converted at various stages to assembled units

In the above paragraph, semi-formal definition given in the first sentence is the core generalization. *Production* is the term being defined, and *as the way material is transformed by factory methods... by society* is the sum of differences, which distinguishes this term from all other members of the class which is not mentioned. Then this semi-formal definition is expanded by example, which is indicated by the phrase *for example*; then by process description in which there is a time ordered series of related activities.

3.5.3. Definition Expanded by Exemplification

One sentence definition is very often expanded by examples to give the reader a specific case or a general one of the generalization represented by the core idea, i.e., by a formal definition (Fahnestock, 2009).

Example 16. Acceleration is a change in the speed or velocity of an object per unit of time.

$$A - v/t$$

$$v - s/t$$

There are two time units in the expression for acceleration for example, miles per hour per hour (mi/hr/hr) or meters per second per second (m/sec/sec).
For example, an automobile at rest has an initial velocity of 0 miles per hour. As the car begins to move, it is accelerated from zero velocity to some new velocity in the first second it moves. The velocity of the automobile changes as long as the acceleration continues. The change in the velocity also can be a negative one. The driver can apply the brakes of the automobile and slow the car down. The change in velocity in this instance is known as deceleration or negative acceleration.

The formal definition given in the first sentence is expanded, first, by a general example since the reader is told that there are two general time units in the expression for acceleration. Then the writer tells the reader a specific case of acceleration of an automobile.

3.5.4. Definition Expanded by Illustration

It is very often found in technical writing. The writer uses it when he wants to make his definition clear by referring the reader to a picture, a graph, or any other visual aid. This kind of illustration is called visual illustration. When the writer wants to give the reader a very specific, detailed example, this type of illustration is a special kind of example and it is called illustration in words.

Example 17. Hardness

Hardness is a measure of the resistance of a material to permanent deformation. It is commonly measured by placing an indenter in contact with the material being tested. A known load is placed upon the indenter, as shown schematically in Fig.1-11(a).The indenter material is much harder than the specimen, with hardened steel, tungsten carbide, or diamond being commonly used. After the indentation has been made, the indented is removed (Fig.1-11b). The hardness number depends on the geometry of the indentation and the type of test used. The type of test often leads to some confusion. The four different types of hardness tests are summarized in Table 1-1, and it is seen that different types of indenters are used for different tests. The hardness number depends on the applied load and the shape of the indentation, for the first three tests shown (Brinell, Vickers, and Knoop). For the Rockwell hardness test, both the shape of the indenter and the load are specified. The hardness number depends only on the depth to which the indenter penetrates the specimen. The hardness tests given in Table 1-1 have been found to be convenient and have evolved as standard tests.

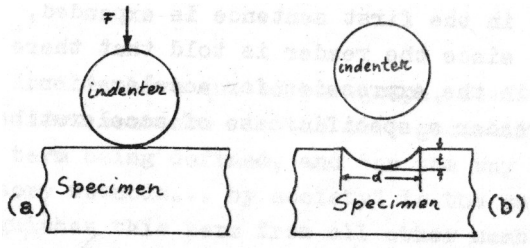

Fig.1 The hardness test (a) A loaded indenter is placed in contact with the specimen.The indenter is shown as a sphere; however, other shapes are also used. (b) The hardness number depends on the indentation that remains when the indenter is removed. The dimension d is used in the Brinnell test, whereas t is used in the Rockwell test. From M.M.Eisenstadt, *Introduction to Mechanical Properties of Materials,* 2012:137

The above definition of *hardness* is expanded by illustration in words and in visual aids. The writer describes how the hardness is measured (tested) by referring the reader to a picture which is supposed to help him visualize the things he is describing.

3.5.5. Definition Expanded by Explication

This is a special type of expanded definition. In this type of definition the writer takes those words in the original definition which are presumed not known to the reader and defines each of them, so that the reader can, when he has read the entire discussion, put together all of the definitions and understand the original definition more clearly (Bazerman, 1998).

Example 18. Fluid Velocity

We define fluid velocity at a point, or the flow velocity (at a point) as the velocity (a vector) of a fluid element relative to a certain reference frame. If the reference frame is not specifically defined, then it corresponds to the reference frame in which the flow is studied. By the flow speed, or the speed of the fluid at a point, we mean the magnitude of the flow velocity (or, in other words, the magnitude of the fluid

velocity at a point). If the flow is uniform everywhere in the region of space considered, we speak of the stream velocity, or of the stream speed.
Note that when defining the fluid velocity at the point we used the concept of a reference frame. Since it is impossible to detect the absolute motion of a system by studying its response to the action of forces, only relative and not absolute motion through space can be detected. This statement describes what is known as the Newtonian relativity. As a result, when we say that a fluid flows we are considering its motion relative to a certain frame of reference.

From: J.P.Freidberg, *A self-consistent two-fluid model,* 2008:78

In the first sentence of this paragraph the writer gives a formal definition of the *fluid velocity at a point* which is also the core generalization. Then he explains what he means by *flow speed*, *stream velocity and reference frame*. Because both physical paragraphs develop the same core generalization they add up to one conceptual paragraph. After the reader has read the entire conceptual paragraph and put together all of the definitions he will be able to understand the original definition, stated in the first sentence of the first physical paragraph, more clearly.

3.5.6. Definition Expanded by Operation

It is a special type of expanded definition in which the writer tells the reader what to do (usually some physical activity) in order to experience the thing being defined. This type of definition is often given as a set of instructions, either direct or indirect, which enable the reader to feel or see or somehow experience the terms being defined.

Example 19. Letterpress Printing and Letterpress Printing Presses

Letterpress printing (sometimes also called book printing) is now considered to be a largely "extinct" process, except for its descendent, flexographic printing, which is winning more and more of the packaging printing market, just as indirect letterpress printing also prevails in certain parts of this sector. In spite of this, it deserves equal treatment with the other two printing processes in this historical section, because it was from letterpress printing that everything else developed. It has still not yet been proven conclusively whether Johannes Gutenberg accomplished his pioneering discovery between 1440 and 1450 in Mainz or in Strassburg, so both towns honour Gutenberg equally. His invention is based on three things: cast print types, a hand-casting instrument to make these types, and a printing press designed for this purpose, which was adapted from the wine presses of the time.
Friedrich Koenig set about mechanizing the hand press completely, which led to the pioneering invention in 1811/12 of the first automatic cylinder press. In the course of the following years both the drive mechanism (e.g., "rack drive", "railway motion", and circular motion – i.e., planetary drive) and the operating principle of cylinder printing presses underwent constant development. In the latter respect, we should distinguish the most important forms: stop cylinder, single-revolution, and two-revolution presses. Common to them all was the back-and-forth motion of the printing form bed, the "carriage." The flat letterpress printing form was attached to it in a lockup form. The carriage ran on rollers and, apart from the two-revolution presses, was moved back and forth by a thrust crank. An impression cylinder positioned above it, which in the case of the single and two-revolution presses rotated continuously, produced the contact pressure (for single-revolution presses it had a double-sized impression cylinder and one revolution per printed sheet, and for two-revolution presses it had a correspondingly smaller impression cylinder and two revolutions per printed sheet); the sheet of paper was brought into contact with it by using a so-called "swing gripper". These sheet feeders in particular underwent numerous further developments up to full automation (Kipphan, 2001).

4. CONCLUSION

Definition is one of the rhetorical functions used by writers of scientific and technical English to provide information about a given concept or object. The process of definition is a natural way the mind works. The purpose of definition is to limit the meaning of a word which stands for an object in an acceptable way. Specifically, definition is an explanation which distinguishes this concept or object from all others. They are expressed implicitly and explicitly in scientific and technical discourse. In a paragraph of implicit definition the defining information is scattered through or mixed with other kinds of information and

should be abstracted from the paragraph and put together as a definition by the reader. They are not explicitly stated but given by implication, thus, they make use of context and, at times, the reader's previous knowledge, to make clear what the given concept is. Explicit definition is the type of definition which makes clear through phrasing that a particular concept is being defined. It is stated obviously and in detail, leaving no room for confusion or doubt.

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