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Jan Rajmund Paśko, Ingrid Paśko

Definitions and nature education

Introduction

Human beings have been exploring nature since the beginning of humankind. Nature is also present throughout our lives. Our attitude to nature evolves as we grow old. Similarly, the progress of civilization has changed our attitude to nature. Back in the mid-twentieth century, society was virtually unaware of how detrimental the blissful exploitation of nature could be to planet Earth. Nature has reached a tipping point where it can no longer deal with man-made pollution on its own. This only leads to the degradation of the natural environment. Eventually, people realized that the further destruction of the natural environment could lead to catastrophe and put life on Earth at serious risk.

Since the beginning of humankind, people have collected information on nature, most notably those types of data they would be able to use. The data were primarily concerned with the benefits and risks that nature produced for human kind. All these data added to the overall human knowledge of nature.

For a long time, nature education at the early stages of instruction was limited to providing factual information. This is best evidenced by textbooks on nature education from the early 20th century (Heilpern, 1917).

Which fields of study belong in the natural sciences? There is no single answer to this question. According to Sawicki, natural sciences include biology, chemistry, physics, and geography (Sawicki, 1981). However, some specialists see physics in the realm of the exact mathematical sciences. The author of *Zainteresowania młodzieży naukami ścisłymi* is a case in point (Elbanowska-Ciemuchowska, 2010). Physics may be regarded as an exact mathematical science because it uses definitions as a means of recording the equality of two expressions, which entails a definition of a particular value in mathematical terms.

In interwar Poland, teaching methodologists distinguished between animate and inanimate nature, and that is best reflected in the respective textbooks from that time (Dmochowska, Ziemecki, 1934, Gayówna, 1937).

Contemporary methods for teaching natural sciences have gone beyond the mere transmission of factual knowledge. The focus is on the acquisition of skills, where pupils are now able to browse for facts in the relevant literature and (increasingly) on the Internet. Arguably, rote learning has now given way to operational learning. The current curriculum in natural sciences stipulates that pupils should be able to group elements according to the provided criteria and transform the knowledge they have (knowledge defined as a combination of skills and factual information). In order to do so, they need to be able to use definitions. The common understanding of a definition is that of classical kind.

Definitions in the process of nature education

The way the very definition of a definition is formulated and how these definitions are divided into classes depends on the author and their field of scientific enquiry. Structural division is considered the most fitting for teaching purposes. For this reason, a division furnished by linguistics will be used in this article (Mortimerowa, 1987). Accordingly, each and every way to elucidate words, terms, symbols, and concepts will be considered a definition.

Definitions can perform a number of functions: they can be used for the purpose of explanation, organization, classification, and identification; they also play a prominent role in interpersonal communication. Since they help to provide a shared meaning for both the sender and the receiver, definitions are also instrumental in the process of effective communication between teachers and pupils.

The role of definitions in nature education cannot be properly described without their prior classification. Essentially, definitions can be divided into two groups: verbalized and non-verbalized. Verbalized definitions can in turn be divided into parsed and non-parsed definitions. Non-parsed definitions can either be synonymous or hyperonymous. Parsed definitions represent the following types: classical, denotational, and contextual.

Nature education begins at the very early years of children's lives. A preliminary stage in the process is that of collecting facts. At this stage, facts are only passed on or taken in from the environment, without prior classification. Children are still unable to say if a particular item of information can be qualified as referring to nature. Their first teachers, who almost invariably are also their parents, provide children with the concepts they are most likely to come across in their environment. Far from systematic, this type of knowledge is more of a loose collection of terms that children come across or descriptions of items to be found in their surrounding environment.

Given the role of definitions in children's lives, which explains the meaning of a particular term or name of an item, one can safely assume that children come across definitions from very early on in their lives. An adult holds an apple in their hand, shows the apple to a child and says: "This is an apple". This statement can be classified with two categories. The first category identifies the name of the object on display. The second points to the object called "apple". The same procedure can be used when defining a plant called marigold. On one hand, it can convey the meaning of a term by pointing out an example; on the other, it can attribute the name to the object on display.

Definitions and explanations are not the only types of information conveyed to pupils, other types include descriptions, accounts, properties, applications, etc. This manner of instruction is used not only at the early stages of education, but also at more advanced levels and even in selected subject glossaries. Pupils, especially at the very early stages of education, are often not able to fish out a definition from the text provided in such a way.

Pupils in early years education often find classical definitions too complex, which is why ostensive definitions are used instead, i.e., definitions which combine words with gestures (Mortimerowa, 1987). Ostensive definitions belong in the category of non-verbalized definitions. Definitions of this type play a prominent role in formative years of education. When someone points to a horse and says "this is a horse", they use an ostensive definition. Definitions of this kind should not be combined with other types of information, e.g. horses are draught animals, they are used for transport or ploughing the fields, etc., horses are now replaced by machines. These definitions are commonly used for defining individual objects. It would be very challenging to introduce children to the natural world without these definitions. Ostensive definitions are also used at more advanced stages of education. For example, a teacher shows a glass vessel to pupils and adds the following verbal comment: "This is a beaker". John Amos Comenius is believed to have pioneered the use of ostensive definitions in teaching, which is best reflected in the following passage: "Surely, then, the beginning of wisdom should consist, not in the rote learning of the names of things, but in the actual perception of the things themselves! It is when the thing has been grasped by the senses that language should fulfill its function of explaining it still further" (Komeński, 1956). However, the ostensive definition poses a certain threat to the process of cognition. As one shows a dog to a child, one barely knows which characteristic traits the child is going to process as those of the dog. That is why children can give the name "dog" to other animals they know. Thus, an ostensive definition is usually formulated in the following way: "This is a/an X", with X denoting the object of the definition.

The classical definition plays a prominent role in nature education. Definitions of this kind are composed of a *definiendum*, copula, and *definiens*. Such definitions are simple in structure, and as such they are easy to understand. The *definiendum* comes at the beginning of the definition, which suggests this part is going to be explained. The copula can take different forms, including words such as "is" or "are." Pupils particularly like definitions of this type, which is also often highlighted in textbooks. If the author fails to highlight the definition, pupils can do it on their own. Textbooks also happen to provide several definitions of one term: A middle-school textbook, which provides three definitions of acid, is a case in point.

1. Acids are chemical compounds that emerge through the reaction of non-metallic oxides with water.

2. Acids denote chemical compounds whose water solutions contain hydrogen cations.

3. Acids are chemical compounds that increase the number of H⁺ hydrogen compounds in water solutions (Kałuża, Reych 1999).

The structure of these sentences suggests that they all act as definitions of the term "acid" and students understand them accordingly. That said, these sentences are hardly correct as definitions, and their educational value is dubious. The correct

equivalent of the first sentence should be as follows: "Some acids can emerge through the reaction of non-metallic oxides with water". The second definition should be: "Water solutions of acids contain hydrogen ions, or, more specifically, oxonium ions". The third sentence should in turn be: "An increase in the number of hydrogen (oxonium) ions in water solutions is caused by acids". For a definition to be correct, it must be reversible and regulative (Kotarbiński, 1986). In reversible definitions, both the *definiens* and *definiendum* must denote the same object. The reversible definition stipulates that A = B, where A is the *definiendum* and the *definiens* is B. For this reason, the definitions presented above are not definitions in the proper sense of the word because they are not reversible, the *definiens* and *definiendum* failing to denote the same object, one designating a broader class of objects than the other.

In the first sentence, the *definiendum* is too broad for the *definiens* to denote it, as in some cases acids emerge through the reaction of metallic oxides with water.

In the second sentence, the *definiendum* is too narrow for the *definiens* to denote it, as substances other than acid solutions also contain hydrogen ions.

In the third sentence, the *definiendum* is too narrow for the *definiens* to denote it, as substances other than acids, too, may cause an increase in the number of H⁺ hydrogen ions.

At certain stages of education, non-reversible definitions are an inevitable part of instruction. Chemical compounds with the NH₂ group in the molecule are a case in point. For school education purposes, the following statement is used: "Chemical compounds with the -NH₂ group in their structure are amines". This statement is absolutely true; however, it is unsuccessful as a definition of amines. It is true that compounds with the -NH₂ in their structure are amines. Nevertheless, selected amines do not contain the -NH₂ group in their structure.

The contextual definition belongs in the category of parsed verbalized definitions. Such a definition is often just a passage in a text or a sentence that may serve as a basis for the classical definition. Definitions of this kind tend to occur in textbooks. The following sentence is a case in point: "Anemometers are used for measuring the speed and direction of wind" (Encyklopedia geografii, 1999). The passage provides information on what an anemometer is. This sentence can also be used to formulate the classical definition of an anemometer. Thus, such a definition could be formulated as: "An anemometer is a device measuring the speed and direction of wind". This definition is in line with definitions from encyclopedias of natural sciences (Encyklopedia geografii, 1999). Definitions of this kind are more difficult to take in because the receiver has to identify the *definiendum* and match it with the part of the sentence containing the *definiens*. Some methodologists of teaching natural sciences argue that contextual definitions are more educational, as they make pupils analyse the text they read. Instead of being provided with the classical definition, pupils have to understand the contextual definition and then formulate a classical one. Definitions of this kind can be used at more advanced stages of education, be it secondary school or the final years of primary school.

Denotational verbalized definitions are a separate group; they are essentially used for defining collective notions. These definitions play a prominent role in

nature education, most notably at its early stages. That said, they are also necessary at more advanced stages of school education, including secondary school. The definition of electric charge is a case in point, where "there are two types of electric charge: positive and negative".

When defining a notion which is also a set and marking it as "X", the classical definition should not be provided because it is too difficult for the receiver. However, elements "T", "D", or "B" could be included as typical elements of Set "X" without mentioning other elements in the set. Figure R01 illustrates this dynamic.



Denotational definition (general model)

The statement "trees are linden, maple, or spruce" is a typical denotational definition used in the early years of education.

Synonymous definitions belong in the class of non-parsed definitions. The very name of this definition suggests that it provides a synonymous expression rather than explaining the nature of a particular phenomenon. Definitions of this kind explain the meaning of a particular term by providing a term already known to the receiver. That said, synonymous definitions are used too frequently at times. Statements such as "elements are simple substances" fail to elucidate the nature of the elements if the phrase "simple substance" was not previously explained.

Using definitions in classifications

With regard to definitions used in classifications, a study was carried out on the following statement "chemical compounds with the -NH₂ group in their structure are amines". The statement provided above is a non-reversible definition. This definition helps students to classify a particular structural formula as a representation of an amine.

A hypothesis was offered where pupils could classify a particular structure as an amine based on structural formulas and the statement "chemical compounds with the -NH₂ group in their structure are amines".

The statement "chemical compounds with the -NH₂ group in their structure are amines" was an independent variable, while formulas with the -NH₂ group in their structure were a dependent variable. Correct readings of structural formulas were used as an indicator.

The study was carried out on a sample of 106 middle-school third-graders. Pupils were not provided with the notion of amines prior to the study; however, they were familiar with notions such as hydrocarbons and alcohols and their structural formulas. The questionnaire survey was divided into two parts. One part contained the statement "chemical compounds with the -NH₂ group in their structure are amines", the other provided structural formulas of eight different substances, five of which containing the -NH₂ group in their structure. 80% of the pupils provided five correct readings. Other pupils offered between one to four correct readings. Only one pupil offered no correct reading. The research hypothesis was confirmed in the study, demonstrated by the correct readings provided by the pupils.

Conclusions

Seemingly, definitions are easy to introduce in the process of nature education. However, this is far more challenging in practice. The major challenge is the structure of the *definiens*, which cannot contain two terms previously unfamiliar to pupils. In the teaching process, it is vital that in their *definiens* definitions provide terminology that is already familiar to pupils. The authors of encyclopedia entries, including those in subject glossaries, are not obliged to meet this requirement, as encyclopedia or glossary entries are provided in alphabetical order.

Many methodologists of teaching argue that teaching a new section of study should start firstly with presenting natural phenomena to pupils. Since crude oil can be found in nature, it is quite logical that the section on hydrocarbons should start with a discussion of crude oil as a fossil. This procedure seems correct and will surely find a large number of followers. Nevertheless, the definition of crude oil contains the term hydrocarbons, which is going to be introduced later. That is why, from a teaching point of view, such definitions should not be introduced at all. The term hydrocarbons can be replaced with a different term. However, this procedure results in a definition where the *definiens* is too elaborate. For this reason, as demonstrated above, teaching hydrocarbons should start with an overview of hydrocarbons and their definition instead of an overview of crude oil (Paśko, 2013).

The classical definition seems to be the most accurate and unambiguous, and as such it is preferable in the education process. In some cases, it may be difficult or even impossible to use it. The choice of particular types of definitions in the process of nature education is an important task for teachers and methodologists of teaching, most notably authors of textbooks and teachers of natural sciences. When choosing a definition of a particular kind, one has to bear the age of their pupils in mind and, naturally, their previous knowledge of terminology. Teachers should select definitions which contain elements that are already familiar to their pupils. However, pupils must not only know the terminology, but also understand it. Teachers should choose definitions according to their objectives. They should choose contextual definitions.

Nature education is based on observations of nature and experiments performed by pupils. The observation of nature and experimental outcomes serve as a basis for generalizations, which ultimately lead to the formulating of definitions. Definitions are also used when assigning observed elements to a particular set. As demonstrated in the study, a correctly structured definition allows one to assign particular elements to a particular set. This hypothesis was confirmed in a study where pupils were asked to assign amine structures to a set of amines, even though pupils had been provided no previous information on amines in class.

References

- Dmochowska A., Ziemecki S., (1934), *Przyroda nieożywiona (martwa) dla klasy V szkoły powszechnej*, Nakładem Księgarni Rutskiego, Wilno.
- Elbanowska-Ciemuchowska S., (2010), Zainteresowanie młodzieży naukami ścisłymi Diagnoza stanu zainteresowań wybranych grup wiekowych oraz propozycje ich kształcenia, Wydawnictwo Uniwersytetu Warszawskiego, Warszawa.
- Encyklopedia multimedialna Geografia PWN, (1999), Warszawa.
- Gayówna D., (1937), Przyroda żywa dla V klasy szkoły powszechnej, PWKS, Lwów.
- Heilpern M., (1917), *Początki nauki o przyrodzie (Podręcznik dla szkół elementarnych)*, J. Lisowska, Warszawa.
- Kałuża B., Reych A., (1999), Chemia ogólna i nieorganiczna (gimnazjum I cz.), Żak, Warszawa.
- Komeński J.A., (1956), Wielka dydaktyka, Z. N. Ossolińskich, Wrocław.
- Kotarbiński T., (1986), Elementy teorii poznania logiki formalnej i metodologi nauk, PWN, Warszawa.
- Mortimerowa H., (1987), *Hasło definicja*, [In:] Z. Cackowski, J. Kmita, K. Syaniawski, P. Smoczyński (eds.), Filozofia a nauka. Zarys encyklopedyczny, Ossolineum, Wrocław, 79–85.
- Paśko J.R., (2013), *Znaczenie definicji w edukacji przyrodniczej*, Zakład Chemii i dydaktyki chemii UP Kraków.
- Sawicki M., (1981), *Metodologiczne podstawy nauczania przyrodoznawstwa*, Ossolineum, Wrocław.

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Abstract

Natural sciences include biology, chemistry, physics, and geography. The article offers a classification of definitions according to their structure. Different types of definitions were illustrated with suitable examples from the realm of the natural sciences. The article provided typical statements that are used in textbooks as definitions; however, these statements do not meet the structural criteria of a definition. Definitions other than classical and their role in the process of nature education were also presented. Research outcomes were quoted which show that correctly formulated definitions are very useful when assigning particular elements to a particular set. The article also elaborates on teaching methodology to be used when introducing definitions in nature education. Definitions of various kinds play a prominent role in nature education, which is based on observation and experiment.

Keywords: the role of definitions, types of definitions, nature education

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dr hab. prof. UP Jan Rajmund Paśko

Pedagogical University of Krakow, Poland email: janraj@onet.eu

dr Ingrid Paśko

Pedagogical University of Krakow, Poland email: ingrid.pasko@up.krakow.pl