

What Do the Pictures Say in a Science Textbook?

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ABSTRACT

Many studies have demonstrated that images are essential in learning science to help the learners understand abstract scientific concepts. This research aims to investigate the use of images in a science textbook, by looking at the ideational meaning of the images and the captions accompanying them. By doing multimodal analysis, the research focuses on identifying the types of images and types of processes used in the images to identify the ideational meaning. The data for this research were taken from the first six chapters of a chemistry textbook. The theory of reading images (Kress & Van Leeuwen, 2006) and Systemic Functional Grammar (Halliday, 1994) were used to analyse the visual and verbal modes in the textbook. The result of the analysis shows that ideationally, in terms of types of images, the textbook dominantly used realistic images, the one which represents reality in human viewpoint. In terms of types of processes, analytical images were dominantly used in the textbook. Ideationally, the visual and the verbal modes in the textbook complement each other to strengthen the meaning of the scientific concept delivered to the learners.

Keywords: *Ideational meaning, multimodal analysis, reading images, science, systemic functional grammar, textbook*

1. INTRODUCTION

Science is communicated using different modes. The modes in science can be in the form of verbal and visual modes. Science, especially those taught in Indonesia usually refers to four learning subjects, which are Mathematics, Physics, Chemistry, and Biology. Those four subjects are usually communicated using verbal and visual modes. The use of visual modes such as photographs, diagrams, etc., has been part of science for many years (Evagorou, Erduran & Mäntylä, 2015). They had become representations with a technical function in the scientific subject (Kress & Van Leeuwen, 2006). Therefore, as Lemke (1998) said, science is not only communicated through verbal modes alone, but it is a semiotics hybrid in which simultaneously and essentially combines verbal (typological) and mathematical (graphical) modes.

Textbook is one of the learning sources that is essential in learning science. It also applies various semiotic modes including visual and verbal modes to make meanings and to communicate the functions. Additionally, the images presented in the science textbook often accompanied by captions. Captions can be

said as an inseparable part of the images presented in the textbook. Captions are the accompanying textual descriptions of images (Kim, Lamkin & Duncan 2010). They can be used to give more information about the images to the learners. An early work found was conducted by Srihari (1995 cited in Divoli, Wooldridge & Hearst, 2010) on connecting the information between photographs in a newspaper and the caption.

Even though the studies on analyzing the use of images in the textbook have provided sufficient insights on how the images communicating the science (Ajayi, 2012; Bezemer & Kress 2010; Chen, 2010; Haiyan, 2018; Hermawan & Rahyono, 2019; Wilson & Landonhays, 2016), there is an urgency to discover the role of images used in the science textbook and the relation between the images and the captions accompanying them. Therefore, this research seeks to discover the types of images that are frequently used in a science textbook to communicate the scientific concept.

For the purpose of this research, the science textbook that is used is a Chemistry textbook used by the students majoring in International Program in Science Education (IPSE) at UPI, as one of their learning sources.

Specifically, this research investigates the images used in the Chemistry textbook and the captions accompanying the images.

The focus of this research is to investigate the visual and verbal modes of the textbook. For the visual modes, the analysis is limited only to find the types of images and the process used by the images in communicating the science. To achieve this, visual transitivity system based on theory of reading images proposed by Kress & Van Leeuwen (2006) has been used. Meanwhile, the analysis of the verbal modes is limited only to investigate the captions that accompanying the images using verbal transitivity based on Halliday's (1994) systemic functional grammar. The result of verbal and visual analysis is used as a base to uncover the ideational relation between the two modes. Additionally, multimodal analysis is conducted to find the relation between the images and the captions accompanying them in communicating the science since multimodality aims to see how the verbal and visual modes are combined to create a meaningful whole (Kress & Van Leeuwen, 2006).

Theory of reading images is one of the tools that is used to analyse multimodal text in this research. According to Kress and Van Leeuwen (2006), images can also convey the three metafunction of meaning; interpersonal metafunction, ideational metafunction, and textual metafunction. Since this research is limited only to analyze the ideational metafunction, which refers to the function of language that serves to construe and represent human's experience, further explanation will focus on the representational structures of images. Kress and Van Leeuwen (2006) propose visual structures of representation to analyse images, as can be seen on the Figure 1.

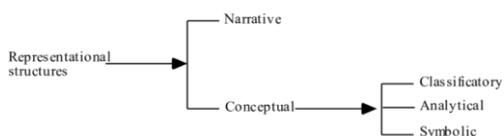


Figure 1 Main types of visual representational structure (Kress & Van Leeuwen, 2006).

The representational structure consists of narrative structures; the pattern where the participants are connected with a vector, and represented as doing something to or for each other, and conceptual structures; the pattern that represents participants concerning their class, structure or meaning, with no vector. Conceptual structure is categorized into classificational, analytical, and symbolical. An image with classificational process connects the participant to each other in a taxonomy

relationship: at least one set of participants will play the role of Subordinate with respect to one another participant called Superordinate. Moreover, an image with analytical process represents the relation between the participants in terms of a part-whole structure. There are two kinds of participants in this process: carrier (the whole) and possessive attributes (the parts). Finally, images with symbolic process tells about what the participants mean or is. There are two participants in symbolic process: the carrier (the participant whose identity or meaning is established in the relation) and the symbolic attribute (the participant that represent the identity or meaning itself). (Kress & Van Leeuwen, 2006).

This research also applies the elaboration of Kress & Van Leeuwen's perspective on the types of images proposed by Dimopoulos et al. (2003). According to Dimopoulos et al. (2003), images can be categorized into three types: realistic, conventional, and hybrid. Realistic image includes all the visual images that represent reality according to human optical viewpoint. Meanwhile, conventional which includes all the visual images that represent reality in a codified way. For instance, maps, graphs, flow-chart, diagrams and molecular structures. Lastly, hybrids image which includes all the images in which elements from both realistic and conventional types are combined.

2. METHOD

This research employs a descriptive qualitative research design. Regarding the descriptive qualitative research design, this research applied multimodal analysis or multimodality since multimodality aims to see how the verbal and visual modes are combined to create a meaningful whole (Kress & Van Leeuwen, 2006). The analysis of the visual modes is limited only to investigate the types of images and the process used by the images in communicating the science, by using visual transitivity system based on Kress & Van Leeuwen's (2006) theory of reading images along with the elaboration on the types of images proposed by Dimopoulos et al. (2003). Meanwhile, the analysis of the verbal modes only focuses on investigating the captions accompanying the images using verbal transitivity based on Halliday's (1994) Systemic Functional Grammar. The result of the verbal and visual analysis is used to find the ideational relation between the two modes.

The data for the research were in the form of visual and verbal data. The visual data were in the form of images taken from the first six chapters of a Chemistry

textbook used in International Program of Science Education (IPSE) study program at UPI. Meanwhile, the verbal data were in the form of verbal captions accompanied the images in the textbook. The research examined 127 images along with the captions accompanying them because the number of sample images and the captions taken are sufficiently representational of the pattern of the whole scientific concept of the Chemistry textbook.

3. FINDINGS AND DISCUSSION

3.1. Ideational meaning of pictures

Types of images used in the textbook

Ideational metafunction can be realized not only through verbal mode but also through visual mode, i.e. images. Images are used to represent and communicate the experiences experienced by humans the same way as the verbal modes are arranged to express the feeling or to respond something (Kress & Van Leeuwen, 2006; as cited in Hermawan & Rahyono, 2019). In the form of graphs, tables, maps, and photographs, science images are essential to learning (Ge, Unsworth, Wang & Chang, 2017).

The result of the analysis shows that there is a significant difference in the types of images used in the Chemistry textbook. The most dominant type of images used is realistic images (92 images). Conventional images and hybrid images are rarely used in the six chapters of the textbook that were analysed. The table below presents the types of images found.

Table 1. Types of images

Types of images		
Realistic	Conventional	Hybrid
102 (80.3%)	23 (18.1%)	2 (1.6%)

As shown in Table 1, the type of images used in the Chemistry textbook is mainly realistic images, which is 80.3% of the analysed images (102 of 127 images). The fact that realistic images, the one which represents reality in human optical point of view, are dominantly used indicates that the textbook aims to give better comprehension to the learners about the complex scientific concept. The use of realistic images also tends to attract the learners more so that they can increase the learners' ability to describe scientific objects (Hermawan

& Rahyono, 2019). The example of realistic image can be seen in Figure 2.



Figure 2 Realistic image (Taken from Earl & Wilford, 2014).

Figure 2 is an example of realistic images that appeared in the textbook. Realistic images in science textbook are relevant with the aim to familiarize the learners with the abstract scientific world (Dimopoulos et al., 2003). The image above supports the claim. Instead of displaying the atomic structure of nickel, the image is displaying a picture of things that can be found in the learners' daily life that use nickel as the material, i.e. coins. Hence, it can be inferred that the dominant use of realistic images in the textbook is most likely aimed to help the learners easily correlate the abstract scientific concept with the objects that can be found in real life.

Other types of images found in the textbook are conventional; images that represent reality in a codified way (18,1% of 127 analysed images), and hybrid, the one which combines the elements of realistic and conventional (1,6% of 127 analysed images). Conventional images are designed according to a techno-scientific harmony in the most concise way (by using graphs, diagrams, maps, and molecular structures) (Devetak & Vogrinc, 2013). Conventional images used in the textbook are mostly used to depict the chemical elements that cannot be seen with human optical or to give an illustration of a complex chemical process.

Meanwhile, hybrids images are rarely found in the textbook. Hybrid images have the potential to stimulate higher-order cognitive processes and thinking skills of the learners (Devetak & Vogrinc, 2013), but only if students can observe the realistic and conventional elements included in one hybrid picture as a whole (Rončević, Čuk, Rodić, Segedinac & Horvat, 2019) so that it would not lead to miscomprehend the scientific concept. In other words, it can be said that the use of hybrid images is rarely found in the textbook because they need to be considered with the learners' comprehension level.

Table 2. Types of processes used in the images

Types of processes used in the images			
Narrative	Classificational	Analytical	Symbolic
29 (22.8%)	12 (9.4%)	84 (66.2%)	2 (1.6%)

In order to understand the abstract scientific concept, the use of images that can enhance the understanding of the learners is needed. Of the three types of images found, the use of realistic images in science textbooks is considered the most relevant for the purpose of familiarizing the learners with abstract scientific concepts (Dimopoulos et al., 2003) compared to other types of images. The reason is that realistic images have certain benefits for the learners, such as speed of processing (Darlan, 2001). Moreover, realistic images can facilitate the learners more when they asked to describe scientific objects (Hermawan & Rahyono, 2019). The use of realistic figures in science textbook also effective to help the student recognize the appearance and structure that are available to visual inspection (Khine & Liu, 2017). Hence, the use of images that are close to the realistic appearance of things in the real-world in science textbooks can make the learners easily understand the conceptual ideas of scientific material that is being delivered.

Types of process used in the images

As already mentioned before, representational meaning of the images can be identified through two types of structures, namely narrative and conceptual structures. Based on the analysis, the research found that there are four types of processes used in the images presented in the textbook. The research found that the processes used in the images are narrative process, classificational process, analytical process, and symbolic process. The following table presents the result of the processes used in the images presented in the Chemistry textbook.

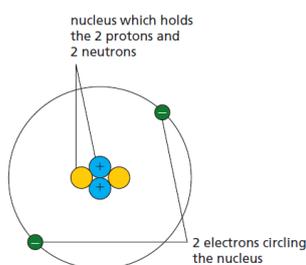


Figure 3.3 An atom of helium has two protons, two electrons and two neutrons.

Figure 3 Analytical Image (Taken from Earl, B. & Wilford, D., 2014).

Of the four types of processes used in the images, the results of the analysis show that analytical process is the most dominant process used in the images presented in the textbook, which is 66.2% of the analyzed images (84 of 127 images). The use of analytical process in the images of science textbooks is believed to increase the learners’ ability in understanding the scientific concept. It is because analytical images allow the readers to analyse the participants (the carrier; i.e. the whole, and the possessive attributes; i.e. the parts) of the images (Kress & Van Leeuwen, 2006). Thus, the dominant use of analytical images is relevant with the aims to increase the learners’ ability on understanding the scientific concept. It is because the chapters in the textbook mostly talk about identifying chemical processes, elements, and phenomena (see Figure 3).

Figure 3 is an example of an analytical image found in the textbook. The image type is conventional, the one that represents reality in a codified way. The representations of codified images are usually realized through graphs, flow-charts, diagrams, and molecular structures. The image above shows an atomic structure of helium. The meaning of the image corresponds to a linguistic equivalent “this atom consists of...” Atom is the smallest particle of a chemical element that cannot be seen with human optical. Thus, by using a codified image in the form of molecular structures, the learners are expected to be able to visualize the atomic structure of helium which is invisible to human’s vision. The use of analytical images in the science textbook shows that they are oriented towards understanding important parts constituting the scientific object and how they relate to each other as a whole (Hermawan & Rahyono, 2019).

Other types of processes found in the images of the textbook are narrative; a process which functions to unfold actions, and classificational; a process which functions to show types of relationship between the things presented in the image. The examples of the narrative and classificational images can be seen in Figure 4 below.

Figure 4 is the example of a classificational image. The image shows a chain reaction of an isotope; Uranium 235. The nucleus of a uranium atom is the superordinate that relates to other subordinates i.e., neutron and fragments. Ideationally, the use of classificational image provides clearer visualization of the taxonomic relationship of the chemical object, since images with a tree structure has the potential to objectify internal knowledge structures of concepts in texts (Ausubel,

1968; Ifenthaler, 2010; O'Donnell et al. 2002 as cited in Ge, Unsworth, Wang & Chang, 2017).

Lastly, the research found that symbolic images (a process which tells about what the participants mean or is) are rarely used in the textbook. The example can be seen in Figure 5 below.

Figure 6 is the example of symbolic image found in the textbook. The image shows a portrait of a man with glasses wearing a coat. The image presented above does not represent any unfolding action or part-whole structure related to the scientist. Instead, the image conveys interpretation beyond its literal meaning (Hermawan & Rahyono, 2019). The position of the man which is in front of the chemical equipment can be inferred that he is an expert in the chemistry field. Ideationally, a symbolic image in this topic is used to show the prominent figure who contributed to the Chemistry field. Since symbolic images convey interpretation beyond their literal meaning (Hermawan & Rahyono, 2019), it might lead to multiple interpretations among the learners. In learning science, the images provided in the textbooks are expected to be able to help the learners in understanding the abstract scientific concept. Therefore, science textbooks tend to use images that are potential in developing the learners' comprehension towards the scientific materials rather than symbolical images.

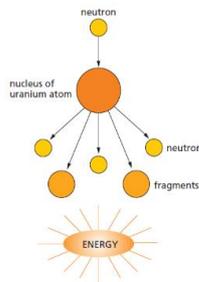


Figure 6.12 Chain reaction in uranium-235 fission.

Figure 4 Classificational Image (Taken from Earl & Wilford, 2014).



Figure 2.2 John Dalton (1766-1844).

Figure 5 Symbolic Image (Taken from Earl & Wilford, 2014).

3.2. Ideational meaning of the verbal captions

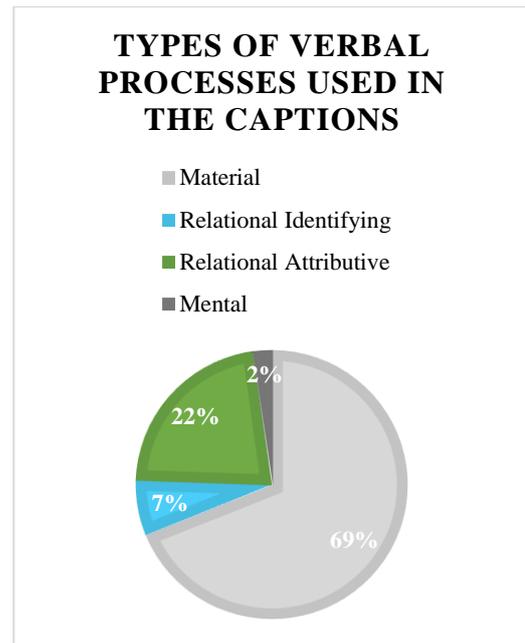


Figure 6 The result of verbal process analysis of the captions.

Caption is an inseparable part of the images, that serves several functions such as: explaining the visual, adding information to general discussion, and can be a combination of both (Darian, 2001). Based on the analysis of the captions using transitivity analysis (Halliday, 1994), the research found three main processes used in the captions accompanying the images; they are material process; the process of doing, acting, happening, or creating, relational process; the process that involves state of being (including having); and mental process; the process that deals with the meaning of sensing (Gerot & Wignell, 1994). Figure 6 shows the processes used in the captions.

The chart above shows that material process is the most dominant process (70%) used in the captions accompanying the images in the textbook. Moreover, relational attributive; the process which assigns the quality to the participant, and relational identifying; the process which establishes the identity of the participant are also found in the captions of the images presented in the textbook. Meanwhile, mental process, the process of describes the meaning of sensing (feeling, thinking, perceiving) of clauses is the one that is the least used in the captions. The following are the examples of the verbal processes of the captions accompanied the images in the textbook.

- 1) Liquid crystals (*goal*) are used (*material*) in this TV screen (circumstance of place).
- 2) This plant (*actor*) produces (*material*) large quantities of drinking water (*goal*) in Saudi Arabia (*circumstance of place*).
- 3) An atom of helium (*carrier*) has (*attributive*) two protons, two electrons, and two neutrons (*attribute*).
- 4) These coins (*token*) contain (*identifying*) nickel (*value*).
- 5) A premature baby (*senser*) needs (*mental:affective*) oxygen (*phenomenon*).

Captioning is also one of the important properties of images to inform the learner what the image is about (Pozzer & Roth, 2003). It is possible to misunderstand what the representation of the image if it has no caption (Akçay, Kapıcı & Akçay, 2020). By looking at the verbal analysis, it can be seen that ideationally, the captions in the textbook dominantly used material and relational process. The use of material process in the captions shows the action of what happens to the object presented in the images. It is used to 'add' the entities' important features in term of what they do (the doing part) and what happens with and to them (the happening part) (Hermawan & Rahyono, 2019). Thus, the use of material process in the captions provides information about the use of chemical elements and what kind of changes that occurs in chemical processes. Moreover, the object presented in the images of the textbook are also described through the use of relational process. The relational process described the parts of the objects and explained how they relate to each other (Hermawan & Rahyono, 2019).

3.3. Ideational Relation Between the Verbal and the Visual Modes

Gleaned from the ideational meaning between the two modes, it can be inferred that there is a pattern in the use of verbal and visual elements in the textbook. The pattern formed can be seen from the position of the images and the captions in the textbook, that complement each other. The captions are always positioned below the images. Furthermore, the ideas that are depicted in the visual modes are also stated in the verbal modes. In other words, it can be said there is an intersemiotic relation formed by the visual and the verbal modes presented in the textbook.

The relation between the two modes can be called as intersemiotic repetition, the relation where the ideas that are depicted in visual mode are also stated in verbal mode. The verbal captions of the images presented in the textbook are always positioned below the images. The relation where ideas that are depicted in visual mode is also stated in verbal mode. Such a relation between the two modes can be interpreted as strengthening the meaning of cross-mode, which combines the meaning of the same experience represented in each mode (Royce, 2002).

The relation between the two modes can be seen from the position of the images and the captions accompanying them which is complementary to one another. The captions are always placed below the images and restating the idea of chemical concept presented in the images. Moreover, the examples also show that the captions support the ideas of the images by giving additional information, and description about what is shown in the image. Thus, it can be said that the captions as the verbal modes serve to strengthen the meaning of the visual modes.

The success of visual modes depends significantly on its relationship with the verbal modes, one of which is the relation between the images and the captions accompanying them (Darian, 2001). In order to understand the ideas of science presented in the image, the learners also need guidance from the captions so that the information contained in the image can be conveyed clearly to them. Therefore, the repetition that occurs in the images and the captions accompanying them is believed to facilitate the learners in understanding the images and comprehending the scientific concepts being delivered.

4. CONCLUSION

By using multimodal analysis, the research aims to find out the types of images and types of processes used in the images presented in the textbook. The result shows that, in terms of the types of images used, the textbook dominantly used realistic image, the one that represents reality according to human viewpoint (Dimopoulos et al., 2003). The use of realistic images in the textbook can be more effective in capturing the learners' attention. Therefore, it can be assumed that the use of realistic image in delivering scientific concept deemed to be relevant with the aim to familiarize the learners with the abstract and complex scientific concept.

Meanwhile, in terms of types of processes, the most frequent process used in the textbook is analytical process, the one that represents the relation between the participants in terms of a part-whole structure (Kress & Van Leeuwen, 2006). The use of analytical process allows the learners to analyse the structure of chemical elements, chemical phenomenon, and chemical processes that is being presented in the image. Thus, by analysing the image, the learners could increase their understanding towards the materials that is being delivered.

The captions accompanying the images were also analysed based on Halliday's (1994) Functional Grammar. By using transitivity analysis, the research found out that material process; the process of doing, acting, happening, or creating, relational process; the process that involves state of being (including having); and mental process; the process that deals with the meaning of sensing (Gerot & Wignell, 1995) appeared in the captions of the images in the textbook. However, material process and relational process are the most frequent processes used in the captions. Dominantly, material process is used to show what happens to and what is done by the chemical objects, also to describe the chemical experiment presented in the images. Meanwhile, relational process is used in the captions of the images to give explanation to the learners about the structure of the chemical elements presented in the images.

Drawing on the ideational relation between the two modes, the research found that there is a pattern formed by the visual and verbal modes in the Chemistry textbook. The captions as the verbal mode are presented below the images as the visual mode. It can be seen that the captions support the concept of the scientific material presented in the images. Moreover, the pattern also shows that there is repetition between the two semiotic modes in the textbook. The captions presented below the images restates the concept of chemistry depicted in the images.

To conclude, the Chemistry textbook used by the students at IPSE UPI uses the combination of visual and verbal modes to provide clearer depictions about the concept of chemistry to the learners. It can facilitate the learners to recognize the scientific ideas presented in the images and understand the brief explanation provided in the captions accompanying the images at the same time. In other words, the images presented in science textbook not only serve to attract the learners' attention, but also

to enable the learners to get better comprehension about abstract scientific concepts.

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