REASONING THROUGH SPONTANEOUSLY GENERATED ANALOGIES

The benefits of using analogies as a conceptual technique to help students familiarise themselves with concepts, phenomena and situations they find abstract and difficult to understand are well documented in science education literature. In most of these studies, students were provided with an analogy, were taught how to use it, and through its use they achieved a meaningful conceptual understanding of the concept, phenomenon or situation they were unfamiliar with in the first place. This paper does not consider the efficacy of such a use of analogies, but rather considers students' spontaneously, self-generated, analogies, as opposed to analogies provided by their teachers or cases in which students were explicitly asked to generate an analogy and reason on its basis. It discusses how the knowledge-in-pieces framework, in which knowledge is viewed as a complex system composed of fundamental knowledge elements that are activated in response to a particular situation, can be used for viewing the relationship and interaction of students' knowledge with their spontaneous analogical reasoning. Data are drawn from a series of small focus group discussions in which students within a number of five age groups (9-10, 11-12, 12-13, 14-15, 16-17) were asked to explain predictions they made when presented with situations they had not considered before. Here, the role of students' spontaneous analogical reasoning in these explanations is examined along with the knowledge they drew upon in order to make their predictions. The findings point to the need for further research on students' spontaneous analogical reasoning and how their existing knowledge affects this reasoning which, in turn, impacts on their understanding of unfamiliar situations and phenomena.

Keywords: Reasoning, Knowledge Construction, Metaphors

INTRODUCTION

Metaphors, models and analogies, as tools for reasoning and instruction, have been of interest to educators and philosophers ever since Aristotle, with extensive research in this area (e.g., Goswami, 2013; Vosniadou & Ortony, 1989) suggesting that they can play a significant role in students' learning and facilitate the teaching of abstract concepts, like those involved in physics (e.g., Greenslade, 2003), chemistry (Sarantopoulos, Tsaparlis & Strong, 2004) and biology (Venville & Treagust, 1996)**.**

Reasoning on the basis of such devices involves a search for similarities between the metaphor, model and analogy (base domain) that students are familiar with and an unfamiliar situation (target domain) they encounter for the very first time. It is a search of similarities between what is new and what is already known with transfer of knowledge from one domain to another enabling students to reach a better conceptual understanding of the target domain.

Although there are some differences and several authors have different concepts in mind when the employ the terms metaphors, models and analogies (Duit, 1991), others have argued that all of these different terms coexist with the latter, they are close relatives are sometimes used interchangeably (e.g., Thomas, 2006). Despite the differences, all these devices are used in an attempt to perceive an unfamiliar situation on the basis of something familiar. The focus in this paper is on whether there is a transfer of knowledge from one domain to another regardless of how this process is referred to and as such, analogy is used here as an overarching term to consider the reasoning process of comparing and drawing similarities between the two domains as shown in Fig 1 below.

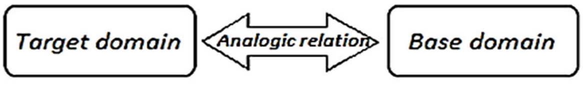

Figure 1. The process of reasoning on the basis of analogies.

1.1 Past research on students' analogical reasoning

Analogies and reasoning on their basis have been studied using a wide variety of methodologies and by mostly focusing on the effectiveness of analogies in terms of promoting conceptual understanding (e.g., Greenslade, 2003; Venville & Treagust, 1996). In most of these studies students were provided with an analogy and, after being taught how to use it, they reached a better understanding of the concept, phenomenon, or situation they were unfamiliar with in the first place. Others (e.g., Pittman, 1999; Wong, 1993) focused on teaching students how to self-generate analogies so as to provide explanations for scientific phenomena and through guidance, refine the generated analogies in order to reach understanding of the concepts involved in the phenomenon under consideration.

Whilst this prior research has added instructional value to the use of analogies, details are still missing as to whether there is any connection between the analogies generated and understanding of new situations as well as the nature of that knowledge in the base domain that students draw on to understand a target they encounter for the very first time. The paper attends specifically to analogies that are spontaneously generated and the interaction of students' prior knowledge with the analogical reasoning process through the Knowledge in Pieces (KiP) perspective (diSessa, 1993).

The following sections briefly discusses the differences between spontaneous and self-generation of analogies and present a brief description of the KiP perspective which is then used to interpret two students' analogical reasoning in a novel situation (situations they have not considered before being asked to make predictions about).

1.2 Spontaneously generated analogies

The term 'spontaneously generated' analogy is used in this paper to denote a self-initiated analogy and, in this sense, a spontaneous analogy is similar to a self-generated analogy. However, self-generated analogy differs from a spontaneous analogy in that whilst a self-generated analogy could be prompted, a spontaneous analogy is always self-initiated.

1.3 Knowledge in Pieces perspective

According to the KiP perspective, knowledge is viewed as a complex system of a fragmented collection of independent, disconnected, knowledge elements that diSessa (1993) named as phenomenological primitives, or p-prims for short. These knowledge elements are phenomenological in the sense that they are minimal abstractions, derived from experiences and closely tied to familiar phenomena. They are also primitive in the dual senses of being activated as whole and in that they do not need further explanation and being evoked as a whole (diSessa, 1993). The activation of particular p-prim, or a set of p-prims, enables a person to explain phenomena observed in the real world in a way that is consistent with the lived experiences that these particular p-prims were abstracted from.

2. METHODOLOGY

The paper reports on a cross-age study in which a total number of 166 students, from five different age groups (9-10, 11-12, 12-13, 14-15, 16-17), were provided with six novel situations in a pictorial form and were asked to make a prediction about the outcome of a future event depicted in the picture. Students had then to write or discuss, during focus groups, what led them to their predictions. The process for selecting the number of students was principally concerned with ensuring a representative sample within the geographical region that study took place. The novel questions were all presented in a pictorial form (Figure 2) so as to be accessible across this wide age range and also to avoid providing any kind of lead in terms of making a particular prediction from those options listed in the accompanying multiple-choice question.

3. RESULTS

The results showed that analogies played an important role in students' reasoning with p-prims coming together, or being activated in combination with, the analogies. This, for example, is illustrated in the response given by a 15-year old student in melting an ice cube in a glass of water novel situation (Figure 2):

> Arrow B should be as the water stays the same and height won't change because it went up when we put the ice cube in it and thus, when it melts it stays there… If I was about to take out the ice cube the water will go down. It is like what I've seen when taking out some sand from my cat's sand-box … the space left is refilled by sand and the height of the sand in the sand-box goes down but here the water from the melting ice takes that space and the water [meaning the water level] stays where it was when we put the ice cube in the glass.

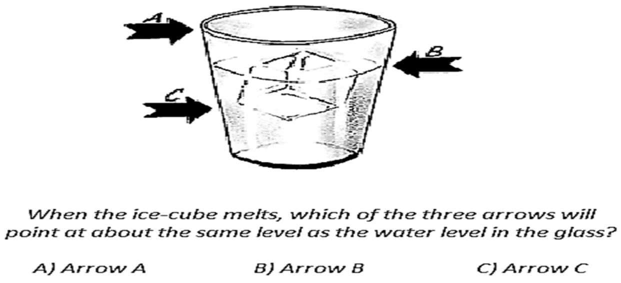

Figure 2. Melting an ice cube in a glass of water situation.

Such reasoning could be seen as being a result of the “equilibration p-prim” (diSessa, 1993, p.141) activation, according to which “a return to equilibrium is the natural result of removing a disequilibrating influence” (p.223). In this case, the activation of this p-prim could be what made students claim that, as long as the ice cube, which caused the rise in the level of the water when placed in the glass (the disequilibration) is not removed from the glass, but simply melted, the level of the water should not change (system is still in equilibrium). Once the p-prim is activated then the role of the spontaneously generated analogy (that of the cat’s sandbag) is to carry the activation back to the target domain and drive the recognition of similarities and judgment of similar mechanisms between the two domains.

4. DISCUSSION

These findings underscore the need to further examine students’ spontaneously generated analogies along with their existing knowledge that, as the study showed, affects their analogical reasoning process. Further research on that reasoning process and the knowledge this is founded upon could contribute towards a better understanding of cognitive models of analogical reasoning and p-prims theory. Such research could also improve learning and teaching of science via analogies by helping curriculum designers and teachers to design analogies that are compatible with students’ existing knowledge and the way they used it to understand phenomena and situations they are unfamiliar with in the first place.

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