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On the Role of Analogies beyond Their Didactic Purpose

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Abstract

Research in science education has extensively defended the use of analogies as an effective instructional tool in facilitating students' learning of science. The power of teaching science on the basis of analogies lies in that it allows students to form cognitive links between what they are learning and what they already know, harmoniously integrating, in this way, the new concepts with their existing ones. Whilst such prior research has added instructional value to the use of analogies in facilitating new concepts learning, what has not yet been studied directly is students' self-generation of analogies and whether there is any connection between these analogies generated and misconceptions students may hold and are found to be persistent and widespread from early childhood to late adulthood.

We report in this paper on a cross-age study in which students from five different age groups were asked to make predictions across a range of novel situations and explain the reasons that led them to these predictions. Having reported elsewhere on the regular use of analogies students drew upon in order to make their predictions, we focus here on the analogies students self-generated per se and their connections to popular misconceptions. According to the findings, students' self-generated analogies revealed not only the misconceptions they hold but also their origins. We suggest, therefore, that the use of analogies should be extended beyond the aim of facilitating the learning of new and unfamiliar concepts by comparing them with a concept or situation students are familiar with. We argue that they can serve as a diagnostic form of assessment revealing both the misconceptions students might hold as well as the prior knowledge upon which these are founded.

Keywords: *analogies, analogical reasoning, misconceptions, diagnosing misconceptions*

1. Introduction

Analogies, metaphors, examples, similes and models are all important sources of reasoning in everyday life when trying to make sense of the unknown and unfamiliar on the basis of comparisons with something known and familiar. Very often, all of these different sources are collectively considered to be analogies as they are based on the same process of making comparisons between a familiar situation or object (base) and an unfamiliar one (target) [1]. Making such comparisons is not only an essential act in people's reasoning but has also proved an innovative and effective technique for solving problems and knowledge development. Thus, it is not strange that the ability to draw on analogies among different situations or objects has been regarded as a relevant characteristic of human intelligence [2].

Within a constructivist approach, analogies also become fundamental in the process of learning [3] as they allow the use of what is known and familiar in order to understand what is new and unfamiliar. In other words, it is usually through the use of analogies that knowledge is built upon prior understandings and experiences. Indeed, extensive research in the area of students' learning has consistently found that analogies can play a significant role in facilitating students' attainment of a conceptual understanding in science. They can be used in the science classroom as an intermediate step between the prior to instruction knowledge and the knowledge to be taught enabling students to transfer either relationships, attributes or both from the former to the latter. An example of attributes transfer, is that of water being analogous to electricity in that they both flow [4], whereas an analogy of relationships transfer, could be that of the solar system for the planetary model of atom as there are similarities in the orbits of planets around the Sun and those of electrons around the nucleus [5]. Given their importance as both intellectual tools and useful resources for learning science, it is not surprising that analogies are present among several instructional devices science teachers use to present.

2. The paper purpose

Whilst prior research has added value to the use of analogies as pedagogical resources, in most of the studies the focus has been on the use of analogies for didactical purposes – i.e., as instructional tools used for the introduction of a new concept with students being provided with a ready-made analogy

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and asked to use it for the comprehension of the new concept. What has yet to be addressed though is the self-generation of analogies by students and the connection, if any, of these analogies with ideas incompatible with the scientific account - ideas that have been widely referred to in the literature as misconceptions.

The present paper presents findings from a cross-age study in which students from five different age groups were asked to make predictions across a range of situations they have not considered before (novel situations) and justify these predictions. Having reported elsewhere on the regular use of analogies students drew upon in making their predictions [6] [7], we focus here on the analogies students self-generated per se and their connections to popular misconceptions.

2.1 The study

A mixed method approach was used in this cross-age study with data being collected through the administration of a paper questionnaire followed by group interviews. In the questionnaire students, whose age ranged from 10-17 years, were asked to make predictions in six novel situations and provide explanations about these predictions. In the group interviews, they were given the opportunity to clarify their answers given in the questionnaire and elaborate further on their explanations. For more details about the study sample, and the research methodology, see our previous work [8] [9].

2.2 Self-generated analogies

The term self-generated is used for an analogy that is self-initiated, in contrast to situations where students are presented with an analogy and they are asked to use it in order to reach an understanding by drawing similarities between the base and the target. In other words, a self-generated analogy has the meaning of an analogy that is generated by the individual as opposed to analogies provided, irrespectively of whether the individuals spontaneously generate the analogy or are somehow prompted to do so.

2.3 Novel situations

The situations in which students were asked to make predictions were novel in the sense that it was unlikely that they would have encountered that situation in the form presented prior to this study and had been drawn from previous research on misconceptions. These situations were presented to the students in a pictorial form so as to be accessible across a wide age range and also to avoid providing any kind of lead in terms of the selection of one particular option from those listed in the accompanying multiple-choice question. In these questions students had to make a prediction about the outcome of a future event (effectively what would happen in the event depicted in the novel situation) and then write what led them to their predictions.

3. Findings

As the analysis of students' responses in the questionnaire and discussions during the interviews showed, the majority of them self-generated analogies in order to familiarise themselves with the novel situations they were presented with and make, in this way, a prediction. The analogies revealed that students held a variety of ideas which were inconsistent with the scientific account.

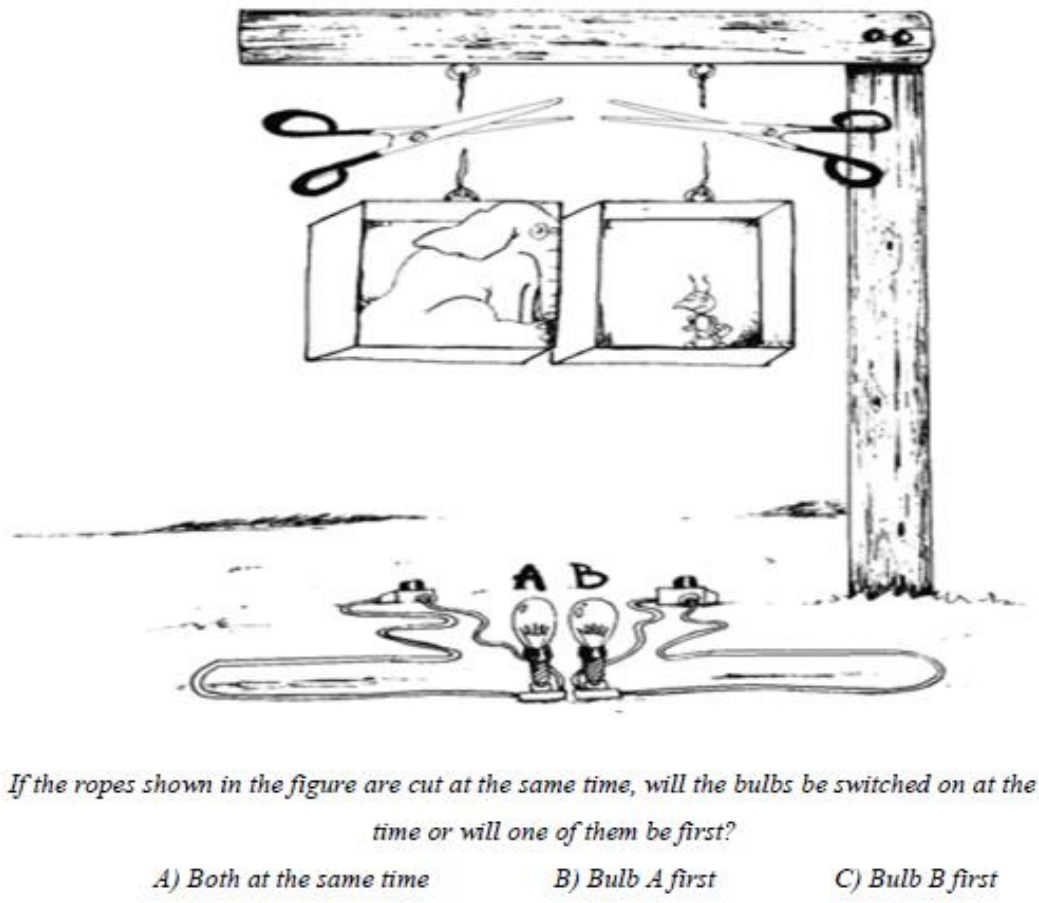

Fig. 1. Weight and gravity novel situation.

Consider, for example, the following response given by a 17-year-old student in one of the novel situations which was set out to probe students' understanding of gravity and the role of weight in falling objects:

> I think this is like when you have a ball and a feather. I have seen a ball falling faster on the ground than a feather. So, I have answered that the box with the elephant in it will fall faster since the weight in it is greater and there is a greater force in that box than in the other one with the ant in it. The heavier always goes faster just like in the case of the ball and the feather.

In this novel situation, students made their predictions by reasoning on the basis of self-generated analogies which were drawn on similar and, in many cases, identical everyday life experiences. It is from a very young age they had seen objects of different mass, like bricks and pebbles or olives and olive leaves –to name a few of the analogies they self-generated- which were left to fall from the same height reaching the ground in different times (the heavier being seen to reach the ground first). In these analogies students articulated a rather common misconception that has been reported in many previous studies with students of similar ages [10 [11]. According to this misconception, the heaviness of an object is seen as being related to its falling speed - a view that is even held by first year university undergraduate students [12].

Students' responses showed that their unique prior knowledge influenced the understanding of the novel situations as well as the generation of analogies through which they approached the novel situations and made their predictions. In turn, as the above response exemplifies, this knowledge was reflected in the analogies students generated.

4. Discussion

The findings suggest that self-generated analogies could be used as a potential approach for the identification of students' misconceptions which challenge the learning of science concepts. Students' self-generated analogies can serve as a diagnostic form of assessment revealing prior to instruction knowledge which gives rise to misconceptions. Such assessments could provide teachers with

valuable information about students' understanding which can serve as a starting place for the introduction of new scientific concepts.

However, teachers not only need to be aware of students' prior knowledge, but they also need to better understand how they use that prior, often experientially grounded everyday knowledge as our study showed, when thinking about new phenomena and situations (like the novel situations used in our study). The use of analogies students self-generate can provide the teacher with an understanding of the ways in which students apply such real-world knowledge. In this respect, a better understanding of the self-generation of analogies and their application could be a valuable tool in assisting teachers to address students' misconceptions. Conversely, with self-generated analogies reflecting where students' knowledge stem from and revealing the sources of their misconceptions, they could be used in order to help teachers further in the identification of the latter.

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