



## Students' Use of Analogies in Making Predictions in Novel Situations

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### Abstract

*This cross age study was designed to investigate how students make predictions in novel situations and the role which self generated analogies play in non-scientific reasoning. Mixed methods were used combining group discussions with questionnaires. In order to meet the needs of the study one age-group from each level of the Greek education system were recruited. Thirteen, sixteen and twelve students participated from Year 4 (primary education), Year 9 (secondary education, Greek 'Gimnasium') and Year 11 (secondary education, Greek 'Lyceum') respectively from three different schools in Greece. Nine focus group discussions were conducted in combination with the administration of a six pictorial item questionnaire. Data were collected through the use of the written questionnaire responses and the discussions which were audio-tape recorded. Students' responses were analysed to ascertain whether students' predictions drew on the use of analogies. Also, responses were analysed to see if students of different ages drew on the same analogies when made predictions in the same novel situations. It emerged that there were many similarities among students' predictions as well as the analogies that students used to explain the latter. For the explanations students provided for the predictions they made a total of 21 analogies were identified. The findings indicate that connecting analogies to novel situations was important in the construction of predictions. The children in Years 4 and 9 made the same predictions using similar, and in many cases identical analogies in their predictions. Whilst students in Year 11 made the same predictions and did make use of those same, similar, analogies the frequency with which they drew on analogies to make predictions appeared much less than for the two younger groups. This study found that students regularly make use of analogies, rather than scientific thinking. Results also indicated that the analogies students use derived from phenomena they observe at a very young age. Teachers need to be aware of the nature of analogies students make use of in order to help them use the analogies correctly and in accordance with concepts they are taught facilitating the way they make sense of abstract scientific knowledge.*

### Introduction

Analogies as tools for instruction and analogical reasoning have been of interest to scientists, educators and philosophers ever since Aristotle. Reasoning on the basis of analogies has been suggested as a key process in human cognition [1] and as a crucial factor in learning at all ages. Research in this area has consistently found that analogies play a significant role in students' understanding and learning about natural phenomena [2].

Learning from new experiences by making comparison with what is already known is central to a constructivist perspective on learning. Within a constructivist approach the learning process involves a search for similarities between the unfamiliar and the familiar, between what is new and what is already known [3]. Therefore, apart from being useful as instructional tools, analogies are also valuable as tools for reasoning and understanding.

Transferring knowledge from one domain (the known and familiar situation) to another (the new situation) enables the individual to reach a better understanding of new information. Using analogies can help people to better understand a new situation by allowing them to see similarities (albeit possibly erroneous ones) between that new and hence unknown situation they are presented with a more familiar situation one [4].

Whilst previous studies did provide an insight about the effectiveness of analogies as a tool for understanding new phenomena, they did not consider the extent to which a particular analogy could be an important factor in finding out how and why students made either incorrect or correct predictions in novel situations. As such, details are still missing as to if there is any connection between the analogies generated and misunderstanding of situations. Moreover, as several authors have argued [5][6], self generated analogies might serve as a diagnostic form of assessment thus revealing any misconceptions that might be held.



This paper presents the findings from a pilot study that investigated students' use of spontaneous and self-generated analogies when making predictions in novel situations. It also investigated the possible relation of the analogies generated with incorrect predictions made. Accordingly, this study was guided by the following four research questions:

- a) What predictions do students of different ages make regarding novel situations?
- b) How do students make predictions regarding novel situations?
- c) Do students draw on analogies when making predictions and if so, on what analogies do they draw on?
- d) To what extent do students of different ages draw upon similar analogies?

Theoretical framework

#### Analogy

In this study we assume in terms of structure analogies to be like examples, models or metaphors albeit there are some differences. Analogies, metaphors, models and examples are viewed as having many similarities and there are different authors that have used these terms interchangeably whereas others have different concepts in mind when they employ these terms [7]. We consider analogies to be a process used to compare structures between two domains and map relations from a familiar domain (base domain) to an unknown one (target domain) (Figure 1). The latter is the unfamiliar situation that is under examination whereas the former refers to the known situations which will form the basis to approach the target.

In an analogy each of the two domains has certain relationships or attributes which can be mapped as being quite similar. An example of attributes mapping is the analogy that water is like electricity (they both flow) whereas a mapping of relationships could be the solar system as an analogy for the planetary model of the atomic structure (similarities in orbits between electrons around the nucleus and planets around the Sun).

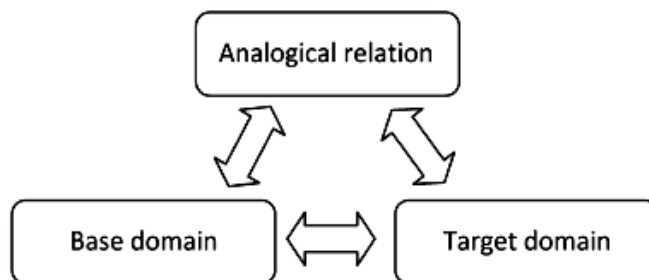


Figure 1. Basic elements involved in an analogy

#### Spontaneous analogies

In the present study spontaneously generated analogy has the meaning of self-initiated in contrast to other situations where the subjects are presented with an analogy and are asked to use in order to understand a new situation. Similarly, a self-generated analogy has the meaning of an analogy that is created by the individual as opposed to analogies that are provided. Both self-generated and spontaneously generated analogies are created by the individual, but the basic difference between the two is that the latter is a self-initiated analogy whereas in the former case the individual might be asked to generate an analogy.

Clement [8] identified three methods for producing spontaneous analogies. These three methods have many features in common with the distinction and a categorisation made by Gentner [9]. These categories are:

- a) Generation based upon a formal principle. For example, a formal abstract principle or a single equation which can be applied in two or more different contexts (e.g. conservation of charge or energy),
- b) Generation via a Transformation. In contrast to the previous method, in this case there is no mention of an equation or a formal principle. Student creates an analogous case B by changing some features of the original case A (modification of the original situation),
- c) Generation through an association. Rather than generating an analogy via a transformation, student is reminded of an analogous situation B in memory. As Clement commented, the analogous case may



differ in many aspects from the original situation but it can still have many and important similar features.

It should be added that Clement observed the first method fewer times in comparison to the other two with the second being the one observed the most frequently.

Research methodology

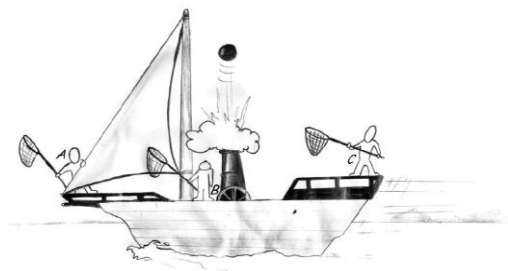
Study sample

The pilot study sample was composed of students from each of the three main levels within the Greek education system. As such the sample comprised thirteen, sixteen and twelve students participated from Year 4 (primary education), Year 9 (secondary education, Greek 'Gymnasium') and Year 11 (secondary education, Greek 'Lyceum') (*students aged 9-10, 15-16 and 16-17 years*) respectively. Being an opportunistic study, the schools were randomly selected from the same geographical region of central Greece representing a population of mixed socio-economic status.

Data collection

Mixed methods were employed. The strategy being used comprised the administration of a 6 item questionnaire each involving both a multiple choice predictive element and an open question designed to probe the rationale for their choice in the former. The situations were novel in the sense that students had not seen them before and, therefore, did not have pre-existing answers for the questions presented to them. All of the situations were in pictorial form, example of which can be seen below (Figures 2 & 3). After completing the questionnaire students participated in semi structured group discussions. Students were asked to further explain their prediction. Discussions were audio-tape recorded.

Novel situation 6: A firing cannon in a moving boat

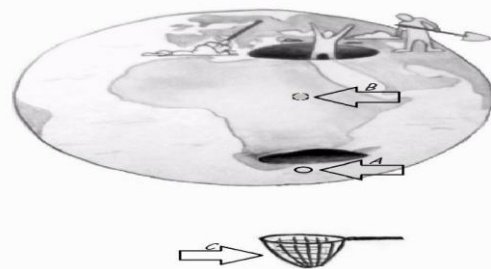


While the ship keeps on moving at the same speed, the cannon fires a ball (as the figure shows). Which person is more likely to catch the ball?

- A) Person A                      B) Person B                      C) Person C

Figure 2. Novel Situation 6 as presented to the students

Novel situation 3: Objects falling in holes dug into the Earth



Two people have dug a huge tunnel straight down from the one side of the earth to the other (as shown in the figure) and one of them jumps in. Where will this person stop?

- A) On the other side of the tunnel                      B) In the middle of the tunnel  
C) In the net

Figure 3. Novel Situation 3 as presented to the students

Data analysis

Group discussions were transcribed. Students' predictions were compared among the three different groups. A modified version of Clement's (1988) framework was used to identify how the analogies were generated. Also, the explanations students provide were classified in three categories according to the way that analogies were generated. Explanations that involved analogies being generated without any provocation were classified as direct spontaneous explanations (DSE). Analogies that were generated as students were asked to elaborate more on their explanation constitute another category, that of indirect spontaneous explanations (ISE). The last category is prompted indirect explanations (PIE). In this type of explanation, students were asked to provide an analogous case with the one already presented to them.

Results and discussion

Most of the students chose the prediction that might have been expected based on the existing literature on both misconceptions and p-prims. Across the 6 novel situations only 18 out of the 240



predictions (7.5%) were correct with students in Year 4 and 9 showing lower achievement. There were many similarities among students' predictions.

All students seemed to be seeking for ways to facilitate their thinking about the novel situations. The majority of them (33 out of the 40 students) appeared to be looking for analogies that would help them in formulating (or selecting) the correct predicted answer. For these predictions a total of 21 different analogy explanations were generated. These were expressed from all students across the three age groups who involved analogies in their explanations.

The largest number of analogies was generated via a transformation; three of them were generated via an association whereas there was evidence for generation via a principle in only one case. The results indicate that the most common method for generating analogies among this study sample was that based on transformation. The majority of the cases that were transformed in order to fit with the novel situations were phenomena that students observed in their early stages of life. This became apparent as some of the older students did use the same analogies such as younger did.

From the 21 analogies, 8 were spontaneously generated (DSE), 10 were indirectly spontaneously generated (ISE) and 3 were prompted by the researcher. Almost half of the analogies identified (12) were used from all the students in the three different age groups. This result indicates that, although spontaneously generated analogies play a key role in the perception of novel situations they can lead to erroneous predictions.

The use of the same analogies from students across the three age groups would suggest that students were lead to faulty answers because of building their predictions on analogous cases based on familiar ideas from personal and daily experiences. Hence, their predictions and their erroneous ideas about the novel situations could be perceived to be stemming from a common way of reasoning and from the use of the same analogies or similar ones.

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