# Exploring the Role of Self-Generated Analogies in Solving and Reasoning About Novel Situations

## Nikolaos Fotou[1]

## Abstract

*Analogies as tools for meaning making have been of interest to scientists, educators and philosophers ever since Aristotle with their use for reasoning being suggested as a key process in human cognition from early childhood to late adulthood. Extensive research in the area of students' learning has also consistently found that analogies as instructional tools can play a significant role in facilitating students' attainment of a conceptual understanding in science. Studies in this area, however, have mostly focused on whether and how analogies provided to the students by teachers and/or researchers can be used effectively in instructional settings. Very few studies have been carried out on the self-generation of analogies by students and how these can be used by the latter in order to understand new information and reason in novel situations. This paper reports on a cross age study in which Greek students from five different age groups (primary and secondary education) were asked to make predictions in situations they had not considered before and describe the reasons that led them to these predictions. According to the findings, students made use of analogies rather than scientific thinking in order to reach a conclusion and make a prediction. In many cases, this analogical reasoning was a non-scientific one as it was based on students' experiential knowledge. This non-scientific reasoning led most of them to make a prediction incompatible with the scientific account but there were also cases in which analogical reasoning was effective in assisting students to understand the novel situations and reach a conclusion/prediction compatible with the scientific account. A cross age comparison of the predictions and the reasons underpinning them showed that students across the five age groups were making the same incorrect predictions as they were reasoning on the same or similar analogies. The discussion of the results point to the need for a better consideration of the analogies students use, and how/why their reasoning on the basis of such analogies could make them misunderstand novel situations.*

## 1. Introduction

Analogies form the basis of much of people's everyday problem solving as they can be used to facilitate the understanding of a new situation by allowing comparisons to be made between that new and unknown situation (the target) and a more familiar one (the base). Making such comparisons is an essential act in people's reasoning and it is on these comparisons that a better understanding of new information could be achieved [1].

Hence, analogies are important elements in reasoning but also, within a constructivist approach, they become fundamental in the process of learning [2]. This is because analogies 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 [3]. This process has been shown to be especially relevant in cases like that of science, in which abstract concepts are involved and their understanding has been found to be difficult from the students' point of view [1]. Students' understanding of these concepts could be facilitated by the use of analogies as these can allow them to conceptualise an abstract, new concept by drawing upon their existing knowledge.

Indeed, science education research has extensively defended the use of analogies as an effective instructional tool in facilitating students' learning of science [2] [4]. Most of these studies however, have focused on the comprehension of analogies provided to the students by teachers and/or researchers but not on analogy generation and its use by the former. Details are still missing on students' self-generation of analogies, their use in facilitating the understanding of a new problem, phenomenon or situation and whether the understanding reached is compatible with the scientific account or not.

The present paper reports on the results of a study designed to investigate how students of different ages make predictions in situations they had not considered before being asked about. The study also

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[1] National University of Ireland (NUIM), Ireland

examined whether students draw on analogies to make their predictions, as it has been plausibly suggested in several studies [5, 6], and if so, whether the predictions made are in agreement with the scientific account.

## 1.2 Analogies, metaphors and similes

Analogies, generally speaking, have two main components - the base and the target. The former refers to the familiar and already understood situation, whereas the latter is the unfamiliar and unknown situation, which is under consideration. Both the base and target have certain relationships or attributes that can be mapped as being quite similar.
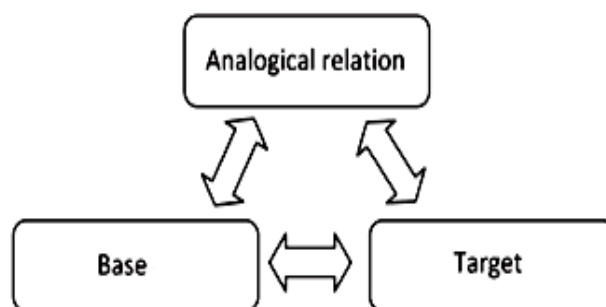


Figure 1. Basic elements involved in an analogy

An example of attributes mapping, discussed in detail elsewhere [7], is the water analogy according to which water is like electricity (they both flow), whereas a mapping of relationships could be that of the solar system being analogous to the planetary model of the atomic structure (similarities in orbits between planets around the Sun and electrons around the nucleus) [8]. In this sense, an analogy is a detailed comparison that 'works' by drawing on various relationships or attributes of both situations in order to illustrate similarities between them, which can then be used as a basis to infer additional similarities to other aspects of the base-target system (Figure 1).

## 1.3 Self-generated analogies

As has been defined elsewhere [9], the term self-generated is used to denote an analogy that is self-initiated, in contrast to situations where students are presented with an analogy and they are asked to use that to draw similarities between the base and the target in an attempt to understand the latter. In other words, it has the meaning of an analogy that is generated by the individual as opposed to analogies provided, irrespective of whether the individuals spontaneously generate the analogy or are asked to do so.

## 1.4 Novel situations

A 'novel situation' is an unexpected and unique event or scenario that has neither previously been encountered nor anticipated [10]. The situations used in the study reported here were novel in the sense that it was unlikely (although this was not in itself necessary) for the students taking part to have previously encountered these specific novel situations in the form presented to them. Therefore, students would not be able to recognize them so as to solve them by giving a ready-made, pre-existing answer [8, 9].

## 2. Research methodology

The study took place in Greece and there was a sample of 166 students aged from 10 to 17 years recruited. A paper and pencil survey was administered followed by focus group discussions. In the former, students were presented with six novel situations in a pictorial form and were asked to make a prediction about the outcome of a future event (effectively what would happen in the event depicted in the novel situation), solving this way the novel situation. Students were then asked to provide written explanations about what led them to their predictions. The focus of the group discussions was the predictions and the explanations provided. All the concepts involved in these six novel situations had been drawn from previous research on misconceptions. More details about the study sample and the research methodology can be found in previous work [9, 11].

## 3. Results and Discussion

According to the findings, just over 80% of the students who took part in the study made an incorrect prediction suggesting a lack of understanding of the concepts involved in the six novel situations. The incorrect predictions students made were those that might have been expected based on the existing literature on students' misconceptions that the novel situations were set out to probe. The explanations provided showed that students solved the novel situations by reasoning on the basis of self-generated analogies which were, in turn, derived from their everyday experiences. The analogies were generated *in situ* and functioned as the base enable them to transfer information from that analogous situation to the target, albeit students said they were unfamiliar with the latter. In this way, they became more familiar with the novel situation and by applying the conclusions they reached from the base to the target they made their predictions. The analogies students self-generated simply provided them with a situation in which they knew the answer, was meaningful to them and they thought that the same answer, or a very similar one, would also be the solution to the novel situation they were trying to reason about. At least four in every nine students used an analogy in all six situations in order to explain what led them to their predictions with the self-generation of analogies being evenly distributed across the five age groups (for the figures and a more detailed discussion, see previous work [12]). The analysis demonstrated no statistically significant association between students' age and the use of analogies in making predictions [12]. The majority of these students (at least 86%) who solved the novel situations by reasoning on the basis of analogies were led to an incorrect prediction. There was also no statistical difference found between the use of analogies that led to an incorrect prediction and students' age [12]. Therefore, the origins and widespread prevalence of the incorrect predictions made across the whole age range could be better understood as arising from the fact that the majority of students reasoned on the basis of the same, or very similar, analogies.

Students' self-generated analogies identified in this study were found to be corresponding to their personal views and deriving from their experiential knowledge. As has been argued elsewhere [11, 12], these views and kind of knowledge tend to promote misconceptions and be overgeneralised in contexts in which they do not apply, leading this way to an understanding incompatible with the scientific account. Therefore, the findings are suggestive of the use of analogies beyond their didactic aim - i.e. teachers providing ready-made analogies to the students to support and facilitate the learning of concept. Students' self-generated analogies can be used as a diagnostic form of assessment for the identification of their incorrect ideas but at the same time, the teacher can use them to gain valuable insights about how students reason and understand the newly introduced and unfamiliar concepts.

## References

[1] Mozzer, N. B., & Justi, R. "Science teachers' analogical reasoning", Research in Science Education, 2013, 43(4), 1689-1713

[2] Haglund, J. "Collaborative and self-generated analogies in science education", Studies in Science Education, 2013, 1-34

[3] Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. "Constructing scientific knowledge in the classroom", Educational Researcher, 1994, 23 (7), 5-12

[4] Cheng, M., & Brown, D. E. "Conceptual resources in self-developed explanatory models: The importance of integrating conscious and intuitive knowledge", International Journal of Science Education, 2010, 32(17), 2367-2392

[5] Inagaki, K., & Hatano, G. "Young children's naive thinking about the biological world", New York, Psychology Press, 2002

[6] Vosniadou, S., Skopeliti, I., & Ikospentaki, K. "Reconsidering the role of artifacts in reasoning: Children's understanding of the globe as a model of the Earth", Learning and Instruction, 2005, 15(4), 333-351

[7] Fotou, N., & Abrahams, I. "Doing with ideas: the role of talk in effective practical work in science", School Science Review, 2015, 97(359), 25-30

[8] Fotou, N. "Students' use of analogies in making predictions in novel situations", Conference proceedings, New Perspectives in Science Education, 3rd Edition, Italy, Libreriauniversitaria.it, 2014, 336-341

[9] Fotou, N., & Abrahams, I. "Students' reasoning in making predictions about novel situations: the role of self-generated analogies", Insights from Research in Science Teaching and Learning, Switzerland, Springer International Publishing, 2016, 123-138

[10] Fotou, N., & Abrahams, I. "Preliminary findings regarding students' predictions in novel situations: The role of self-generated analogies in non-scientific reasoning", A paper presented at the ESERA conference, Nicosia, Cyprus, 2013

[11] Fotou, N., & Abrahams, I. "Students' analogical reasoning in novel situations: theory-like misconceptions or p-prims?", Physics Education, 2016, 51(4), 1-6

[12] Fotou, N. "Students' predictions in novel situations and the role of self-generated analogies in their reasoning", Unpublished doctoral thesis, University of Leeds, UK, 2014