SCIENCE VIA FICTIONAL NARRATIVES

COMMUNICATING SCIENCE THROUGH LITERARY FORMS

AQUILES NEGRETE

INTRODUCTION

What are the possible outcomes of science and art interaction? How should science be communicated? Can we remember scientific information included in fictional stories? Can we communicate science through literature? What are the differences of learning through factual texts versus fictional stories? How science credibility is affected when information is communicated in a fictional narrative way? These are some of the questions that inspired this research.

Quite often one needs more than the traditional teaching tools in order to explain complex scientific theories to students. To illustrate this I will refer to my own experience in biology. When I was an undergraduate student I found it hard to fully understand evolution by natural selection. It was not until I read a short story, in a book of Russian science fiction, that I penetrated the full meaning of those concepts. That story is "Crabs take over the island" by Anatoly Dnieprov, about an experiment of Darwinian natural selection with crab robots. The purpose of such experiment is to produce compact efficient crabs as weapons for warfare, where the robots could be used to eat the enemy's metal reserves. In this 'struggle for existence' those crabs better adapted to kill the other members of the robot-crab species (an intra-species competition) were the ones who survived. So in every generation those characteristics that resulted in better adaptations for surviving were fixed. For some reason, the experiment goes wrong and the survivor of the struggle is just one gigantic crab. The last scene of the story is this cyber-crab chasing the research leader to obtain the last piece of metal on the island: a tooth filling inside the scientist's mouth.

When I was lecturing on evolution, I found that the best way of teaching some of its concepts and theories was to ask the students to read this kind

Psychology Department, University of Bath, England.
pspan@bath.ac.uk / aqny@yahoo.co.uk

of short stories before the class. I found that in this way it was easier to introduce, explain and discuss evolutionary themes. Unfortunately, I could not find one appropiate story for every difficult concept that I had to explain throughout the course.

I believe that by using short stories it is possible to put in action, in a few pages, a process that in evolution could take place over millions of years. Only fiction can provide us with the possibility of creating these hypothetical worlds in which we can illustrate evolution (and perhaps other complex ideas) in a few minutes rather than millions of years. This is because fiction has no restrictions; the occurrence of processes can be magnified or condensed at the writer's content. To fully understand evolution it is important to somehow witness the process; if we look at it just from where we stand, we get a motionless picture. In this sense, a short story, for instance, can be understood as model that enables us to simulate complex processes and make them work in a particular situation and in a particular time scale. This is closely related to what Yuri Lotman calls a "secondary modelling system" (Lotman 1990).

This is an idea for teaching in a classroom, very much in support to N. Gough's plea for more diversity in the communication resources used in science education (1993). I believe that literary works, like the previous example, could be successfully used to communicate science not only to children or students, but also to the general public.

The challenge to science communication is to establish a bridge between science and the general public. To this end it is necessary to translate science into some common language that allows the reader to become interested and excited about scientific information. Science communication is not original in the scientific content that it conveys, but it is so in the way that it presents the information, and this is precisely what creates an important challenge to this discipline.

Science textbooks have been privileged over other means in science education, but in fact, science and technology are largely represented in the media such as radio, television, magazines, as well as in music, cinema and a diversity of examples in fictional literature including drama. If we are to educate society in and about science, as Nunan and Homer (1981) propose, we have to treat equally all of the cultural media on science. We have to consider in particular science fiction, science fantasy, drama, and other forms of narratives that include science as a theme, which are cultural expressions of the history of science in our society, receptacles of scientific knowledge and important resources for science communication.

Although an effort has been placed on producing science communication, very little has been employed in evaluating it (Gregory and Miller, 1998). How much science is the public learning from exhibitions, newspapers, magazines, films and other popular media? Little is known. More research in this area is clearly needed, as the information resulting from such investigations will provide us with important feedback to develop the work already underway.

How can we measure the success of communicating science?

The majority of studies of science via the media have been about newspapers because they are the most effective way, in terms of time and money, to study a mass medium. Nevertheless, other important means to communicate science exist and very little has been reported about them (Gregory and Miller, 1998). This is the case of fictional narratives.

Here I will suggest that literature is an alternative and effective media to teach science, as Gough, Appelbaum, Weinstein and Weaver suggest. In a broader sense, those narratives represent an important means for science communication to transmit and recreate information in an accurate, memorable and enjoyable way. I also propose in this work a methodology to measure the effectiveness of such narratives in communicating scientific information.

A preliminary study to the one reported here showed that, with different degrees of accuracy, people were able to remember scientific information contained in a short story. From the results of this previous study three basic questions emerged: what type of memory is being used to remember such knowledge? How efficient are narrative texts compared with factual ones in communicating science? And by which of these two written expressions does the information obtained stay longer in the memory?

For this study, learning is defined as the process by which past experience influences present behavior. Memory is a possible way for assessing learning, and different memory tasks indicate different levels of learning, with recall tasks generally eliciting deeper levels than recognition ones (Stainberg 1998). According to Stainberg, in cognitive psychology there are two forms of memory: explicit and implicit. While explicit memory implies a conscious recollection, in implicit memory performance is assisted by previous experiences that we do not consciously and purposely recollect. There are three basic tasks for measuring explicit memory: declarative-knowledge task; recall tasks, and recognition tasks. In measuring implicit-memory two tasks are distinguished: implicit-memory and tasks involving procedural knowledge. From the previous groups, in this study I implemented three of the tasks for measuring explicit memory: declarative knowledge; recognition, and recall, plus one task for measuring implicit knowledge: procedural knowledge.

Declarative knowledge refers to recall facts. Recognition implies selecting or identifying items that an individual learned previously (*e.g.*, multiple choice). Retelling deals with producing a fact, a word or any other item from memory. Finally, tasks involving procedural knowledge are those where the person must remember learned skills and automatic behaviours, rather than facts.

A combination of measurements of explicit and implicit memory provided me with a learning measure and therefore an estimator of science communication success.

OBJECTIVES

1. To develop a method for assessing the effectiveness of different narratives for communicating scientific ideas used in the first pilot study.
2. To investigate the extent to which people can understand, remember and learn scientific information included in a short story compared to traditional factual texts.
3. To explore the motivational dimensions of literary stories as a tool for communicating science.

METHODS

Stories with scientific themes written by famous writers, Primo Levi (1999) and Anatoly Dnieprov (1969), were adapted to enable the participant to read the story and complete the questionnaire in an hour session (two A4 pages). The study included a contrast between factual and narrative scientific information, and compared the extent to which the information was remembered, by answering questionnaries, at two different times (immediately after reading and one week later). A group of forty undergraduate students participated in the study, divided into two subgroups: one read the short stories and the other a list of scientific facts taken from such stories. A statistical test was performed to compare the performance of the two groups (T test).

The questionnaires included two basic forms of questions: multiple choice (identify), straightforward, and open-ended questions (recall). There was also a section where the participants were asked to retell the stories or recall the lists of facts (free-recall) and a section where they were presented with a hypothetical situation in order to explore procedural knowledge. The hypothetical questions also intended to evaluate the capability to put the information in context, to use the information or, in a broadest sense, to learn.

In order to perform a comparison between factual and narrative information, I extracted from each story a list of all the scientific facts mentioned in them. In this way, most of the scientific information included in each story was transformed to individual sentences that mention these facts in a plain textbook style and isolated from the story (the extreme opposite of narrative form). A specific questionnaire was designed for the stories and another for the facts, both equivalent in number of questions regarding scientific information and tasks to be completed.

A second session (one week after the reading) was included to explore differences in the amount of information retained over time depending on the way that scientific information was presented to the participants, in narrative or in factual form. Included in this second session was a general questionnaire to comment on the exercise and to explore the participants' attitude towards science communication through the two different written expressions.

TABLE 1
The structure of the sample.

	Group 1 (Narrative)	Group 2 (Factual)
Session 1 (reading day)	Two stories * Two questionnaires	Two list of facts Two questionnaires
Session 2 (a week latter)	Two questionnaires One general questionnaire	Two questionnaires One general questionnaire

* The stories are *Nitrogen* by Primo Levi and *Crabs take over the island* by Anatoly Dnieprov.

RESULTS AND DISCUSSION

In the first session the factual group performed better in all the tasks, and in general terms the standard deviations of the narrative group were higher than the factual ones. Altogether there was a better performance from the factual group in terms of score and homogeneity in the first session.

The second session showed important changes in the way people retain information. With the exception to recall *Nitrogen*, in the rest of the tasks the differences in performance between the narrative and the factual groups diminished. The initial tendency of the factual group to better accomplish all the tasks changed, and the narrative group performed better in the second session in three out of eight tasks, equally in two and worst in three (table 2).

TABLE 2
Performance of the narrative and factual groups in the second session.

Crabs	Retell	Identify	Recall	Context	
Stories	49%	70%	63%	66%	% *
Facts	49%	77%	70%	52%	% *
Stories	1.73	0.79	0.99	0.20	STD
Facts	1.30	0.34	0.50	0.20	STD

Nitrogen	Retell	Identify	Recall	Context	
Stories	52%	97%	59%	45%	% *
Facts	30%	78%	67%	47%	% *
Stories	1.28	0.31	0.70	0.25	STD
Facts	1.62	0.25	0.73	0.27	STD

* The percentage represents a measure of how close to the ideal the groups performed.

The behaviour of the groups in the different tasks matches Stainberg's observation that recognition memory is usually much better than recall (Stainberg 1998). It is interesting though that the factual group experienced a statistically significant decrease in score in all the tasks from one session to the other ($t(15)=5.899$; $p<0.001$), while the narrative group presented a gradual drop in performance (which was not significant) and in some of the cases scored even better in the second session.

Despite a more homogeneous performance by the factual group, in most of the tasks the differences between the first and the second session's standard deviation augmented in the factual group and diminished in the narrative one. The dispersion of the data suggests that while the information presented as lists of facts looses uniformity in time, the information presented in narrative forms tends to retain better homogeneity. The results also suggest that in time the differences between the performances of the groups tend to diminish (figure 1).

Figure 1 shows a comparison between facts and stories in the two different stages of time. The Y-axis represents a combined measure adding the four tasks for measuring memory in one value (retell, identify, recall and contextualise (RIRC)).

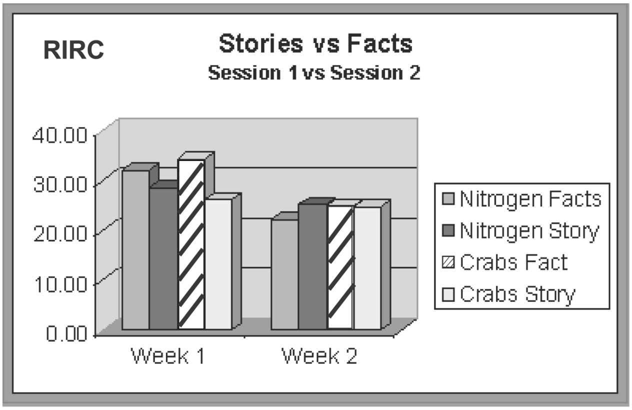

FIGURE 1
Stories versus facts compared in week 1 to week 2.

Qualitative data also offered important information about the way people receive and retain scientific information. Analyzing the scientific information in terms of its role in the story (plot, *dénouement,* surprise ending or background), a suggestion arises that there is a relationship between how central to the development of the story the scientific information is, to how memorable it becomes. In other words, as the scientific information is closer to the important moments of the narration, higher in hierarchy with respect to the plot, it is more likely to succeed in communicating and making such knowledge memorable.

It is also worth noting from qualitative analysis that people often remember and retell information quoting verbatim literary phrases, analogies, metaphors and ironic turns. These verbatim quotations when retelling or giving answers suggest that people retain information when it is presented in an attractive way. Apparently, the literary effects mentioned above enable to evoke emotions in the reader and, therefore, information linked to this emotional response results more memorable.

From the analysis of the general questionnaire in the second session two important conclusions can be derived. First, participants of both groups supported the idea that science can be learned through literary stories and that this represents a more enjoyable way of learning compared to traditional textbooks. And second, they perceived the short stories as a reliable and trustworthy way of acquiring scientific knowledge.

The results of this study as a whole suggest that science can be learned through literary stories and that this represents a more enjoyable way of learning compared to traditional texts. That narrative information is retained for lengthier periods than factual information in long-term memory and that narratives constitute an important means for science communication to transmit information in an accurate, memorable and enjoyable way.

At present I am conducting a study which includes a third measure in time. My hypothesis is that differences not only will diminish but also will reverse in time. Following this line of thought, the changes in performance will also support the idea that although people are capable of remembering and retelling factual information better immediately after reading, in time information presented in a narrative form represents a more memorable vehicle.

BIBLIOGRAPHY

Appelbaum Peter M. (1995), *Popular Culture, Educational Discourse, and Mathematics.* NY: State University of New York Press.

Dnieprov, A. (1969), "Crabs take over the island," in Magidoff, R. (ed.), *Russian Science Fiction.* London: U. of London Press.

Gough Noel (1993), "Laboratories in fiction," in *Science, Education and Popular Media.* Australia: Deakin University.

Gregory Jane and Miller Steve (1998), "Science in public," in *Communication, Culture, and Credibility.* NY: Plenum Press.

Levi, P. (1999), *The Periodic Table.* London: Clays Ltd., St. Ives.

Lotman M.Yuri (1990), "Universe of the mind," in *A Semiotic Theory of Culture.* Great Britain: Indiana University Press.

Nunan E.E. and Homer D. (1981), "Science, science fiction, and radical science education," *Science-Fiction Studies* 8: 311-330,

Sterberg R.J. (1998), *Cognitive Development*. NY: Hardcourt.

Weaver Jhon (1999), "Syntetically growing a post-human curriculum: Noel Gough's curriculum as a popular cultural text," *Journal of Curriculum Theorising* 15 (4).

Weinstein Matthew (1998), "Robot world," in *Education, Popular Culture, and Science. NY: State University of New York Press*