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Effective narratives to communicate science to children

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ABSTRACT

An effective narrative is potentially capable of enhancing the comprehension and engagement of a text. This thesis reviews the literature from the disciplines of Science Education and Science Communication on how to achieve effective narratives to communicate science to young readers in texts. This review shows that each discipline attributes the ability to produce an effective narrative to differences in writing styles. Science Education champions the idea of 'coherence' as the most effective predictor of good comprehension and recall of the text, while Science Communication highlights the ability of 'storytelling' to do so. Since these two ideas are not necessarily contradictory, this thesis proposes a strategy that complements both perspectives. Based on this conception, a ten-step guide to aid the editing of science texts for children is suggested; and an example of a children's book written under this guideline is also included.

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I. INTRODUCTION

Northern Chile has the best skies on the planet for ground-based astronomical observation (Rubio et.al, 2003) because they are cloudless, unpolluted (from dust and light), and also have a steady atmosphere: three essential conditions for successful astronomy. This is why Chile houses[1] 11 of the 35 large optical telescopes [2] in the world. The next decade, the largest earth based telescope, the European Extremely Large Telescope**,** will start operating in the Chilean desert. Nevertheless, the knowledge about how big astronomy is in Chile remains inside the scientific community, as there are not enough communication materials devoted to promoting astronomy to the general public. So far, the only published material for a non-scientific audience is a series of four books about astronomy aimed for readers from 13 years old and over[3]. For younger children, the only published material available is an activity booklet[4] dedicated to astronomy, edited by Explora, the National Program of Non-Formal Education in Science and Technology of Chile, during the International Year of Astronomy (2009). This thesis specifically aims to produce a non-fiction book that introduces children (from age seven and up) to all the major observatories located in the north of

[1] All the big astronomical observatories in Chile are property of international conglomerates that operate with the support of the Chilean Republic.
[2]Large Telescopes have more that 6 m of diameter. (Sebastian Lopez, Chilean astronomer, personal communication).
[3] Chilean astronomers wrote the four books of the series. The titles are: 'Con ojos de gigante' (Barrientos & Lopez, 2008); 'Supernovas' (Maza & Hamuy, 2008); Mundos lejanos' (Minniti, 2008); 'Hijos de las Estrellas' (Ruiz, 2008).
[4] A Spanish version of this publication can be accessed in http://www.explora.cl/index.php?option=com_content&view=article&id=73:publicaciones&catid=60:publicaciones&Itemid=129 (last accesses date 29/062010)

Chile.

The popularization of astronomy is very important in Chile, as the country still lacks of enough astronomers to fully benefit from the observatories. There are currently approximately 50 active Chilean astronomers working for Chilean institutions, when the available infrastructure installed in the country suggests there should be 160[5]. Students need available information of employment prospects to choose a particular career (Tamayose et.al., 2004), thus, less information about astronomy and the observatories as potential work places could mean less enrolment in this career in the future. Consequently, introducing children to astronomy from an early age in order to enhance their interest in this field may be beneficial for the development of this science.

Some researchers have stated that the breaking point of scientific interest occurs at an early age in school, between the ages of nine and fourteen (Hadden & Johnstone, 1983; Shibeci, 1984). According to studies conducted by Murphy & Beggs (2001) with children between eight and eleven years old, younger children have more positive science attitudes than older ones. Therefore, aiming science communication products –like the outcome of this thesis- to children from age seven and over, provides material at an age where children are highly interested in scientific topics; and for whom there are currently no astronomy publications available, at

[5] Web file 'Astronomia en Chile 1: Documento de discusion Chile Ciencia 2000" (*Astronomy in Chile: discussion file Chile Science 2000*) available in http://www.conicyt.cl/dossier/julio/d240703/astronomiacc00.html (last accessed date 16/06/10)

least not about the development of this science in Chile.

The advice

Non-fiction books can be useful products to reach a selected audience and spread a message i.e. that the biggest astronomic observatories of the world are located in Chile and that they need new generations of astronomers to make use of them. Even though the range of audience reached by a book is probably less than the range that other popular media reaches, books have the capacity to trigger a unique emotional response in their readers (Hoogland, 1998) that can be amazingly long lasting. For instance, the famous American astronomer, Carl Sagan, declared that his fascination for cosmology started after reading a book about the stars when he was 9 years old, and that memory stayed with him for the rest of his life (Head, 2006).

However, to leave a positive imprint on the reader the product needs to be a 'good book'. Something the child will enjoy and remember. But what makes a non-fiction book successful, a valuable text? Furthermore, what works and what does not work for a young reader in order to achieve these goals of entertainment and recall? To address this issue, I will need to look at the accumulated knowledge about how to create effective narratives to communicate science to children, and subsequently, apply the collected advice to my own children's non-fiction book.

Overview

The following chapters will explore what the literature suggests are the most effective styles for writing about science for children in order to assure comprehension and engagement.

Chapter 1 introduces the concept of Scientific Literacy and establishes the importance of acquiring this skill at an early age. After identifying the different groups in society that supports the acquisition of Scientific Literacy, the chapter focuses on two of these groups that work with young audiences –Science Education and Science Communication- and how they interact to accomplish similar goals. Chapter 1 also introduces the non-fiction book as a common media that both groups use to communicate with their audience. However, each discipline produces a different style of book –textbooks and trade books– and thus, to understand which are the most effective practices in writing science non-fiction books for children, it is necessary to review each discipline's literature separately.

Chapter 2 addresses the Science Education approach to effective ways of writing about science for children. The chapter contextualizes the status of textbooks in the educational community, and, finding that these texts have been highly criticized for their quality, the chapter examines the most popular techniques that have been used to improve them. Chapter 2 discusses the implications of these techniques and defines to what extent they succeed in enhancing comprehension of non-fiction texts.

Chapter 3 brings the Science Communication approach to effective

ways of delivering science through books. In order to review which are the features that contribute to develop an effective narrative for communicating science in trade books, this chapter discusses the criteria of three actors of the science trade book scene: the book reviewers, who criticize and evaluate the books; the science communicators, who give training and advice on how to communicate effectively; and the writers, who are actually writing the texts. A critical review of their three perspectives together will give a more comprehensive insight about what is need to successfully communicate science to children.

Chapter 4 presents the conclusions drawn from the discussion of chapters 2 and 3. This chapter culminates with a guide to approach effective narratives that reflects the advice of both Science Education and Science Communication perspectives. The suggested guide will be applied in the writing process of the Creative Component of the thesis.

Chapter 5 describes the Creative Component, which is a non-fiction picture book about the giant telescopes that are located in the Atacama Desert, in Chile. This chapter introduces the story and style of the book, explaining concretely how the guidelines drawn from the Literature Review apply to this book.

Finally, the complete version of the Creative Component, the picture book **Look Up!** is attached at the back of this thesis.

II. RESEARCH QUESTION

Which are the most effective ways of writing about science for a young audience?

For the aim of this thesis, a text is considered *effective* whenever the reader is able to both understand and remember the main ideas of the text after reading, and enjoying the content during the reading experience.

III. OBJECTIVES

The main goal of my project is to write a non-fiction book for children which will show all the astronomical observatories that are set in the north of Chile. This book will follow the advice that has emerged from the research in the area of effective narratives to communicate science.

In particular, the aims of this thesis are:

i. To review the available literature on effective narratives that has been produced by scholars in both Science Education and Science Communication fields.

ii. To synthesize the outcomes of this literature into a systematic guideline to address effective writing in popularizing science.

iii. To apply use this guideline in the process of writing the creative component of this thesis.

LITERATURE REVIEW

1. SCIENCE AND THE YOUNG AUDIENCE

"Every kid starts out as a natural-born scientist,

and then we beat it out of them".

Carl Sagan, American Astronomer (1934-1996)

Whether a scientist by profession or not, everybody needs to develop certain scientific skills for life in order to understand, evaluate and validate the information generated in a science and technology dominated society (Thomas & Durant, 1987). This competence is known as "Scientific Literacy", a concept that has too many different scopes and definitions worldwide (Laugksch, 1999), yet for the purpose of this thesis I will adhere to the view of the Organization for Economic Cooperation and Development (OECD), that has been monitoring the economic and social changes of more than 100 countries for about half a century, including the analysis of education and technology patterns. Their vision of Scientific Literacy is committed to raise the living standards of their member countries[6], and to that extent it is more complete than definitions that only cover the acquisition of scientific information by the public.

The OECD describes Scientific Literacy as the "*capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made*

[6] For a list of Members and Partners of OECD see http://www.oecd.org/pages/0,3417,en_36734052_36761800_1_1_1_1_1,00.html (last accessed date 13/08/10)

to it through human activity" (Chapter 3, pg 3, PISA 2003 Assessment Framework – Mathematics, Reading, Science and Problem Solving Knowledge and Skills).

The acquisition of Scientific Literacy is a highly desired outcome of science education at schools, because despite the fact that only a few students will become scientists and enter deeply into scientific knowledge and methods, all children should graduate with the ongoing ability to process new information about health, environment and technology that they will be exposed to during their lifetimes. Maintaining scientific literacy is a way to ensure that society can count on citizens that are aware of the consequences of the choices they make on the world we inhabit and share (if they are appropriate decisions or not is part of a different analysis, but at least resolutions should be the result of an evidence discrimination process).

According to Laugksch (1999), there are four interest groups in society supporting the acquisition of Scientific Literacy. These are:

i) The Science Education Community: mainly concerned about how science is thought at schools (i.e. what to teach, how to teach, how to design appropriate measures of assessment parameters).

ii) Social Scientists and Public Opinion researchers: interested in science and technology policy issues and the general public's support of science and technology.

iii) Sociologists of Science: concerned with the construction of authority with

respect to science, and how individuals interact with scientific knowledge in their everyday lives.

iv) Science Communication community: this is a combined group of professionals that help the general public to familiarize with science through different educational opportunities (through museum displays, exhibitions, among others); and professionals that report and write about science in general (creative teams and the media).

Laugksch (1999) also suggests that these four groups work with different audiences. Science Educators work with children, adolescents and young adults from primary, secondary and tertiary institutions; the second and third group focuses on the "out of school group", while science communicators work with a combination of both audiences.

As the aim of this thesis is to review the effective narratives for communicating science to children, I will focus on the two groups that are concerned about the young audiences: Science Education and Science Communication. Despite these two disciplines sharing a common aim (enhance scientific literacy of the community they work with) and an audience (children) they are seen as separate interest groups mainly because Science Education is part of 'formal learning', which means that it takes place in a school context, it is compulsory, curriculum-based and assessed; while Science Communication is part of an 'informal learning', meaning that it takes place out of the school context, it is voluntary, non-curriculum-based

and non-assessed (Hofstein & Sherman, 1996).

However, the distinction between the two is somehow artificial, because both disciplines are not mutually exclusive, and more over, they work together to educate the public. Science Education makes use of informal learning and Science Communication products regularly, by organizing field trips to the museum or screening popular films in the classroom, for instance. At the same time, many scientists develop outreach activities that involve a direct interaction with schoolteachers and their students (McKnight, 2010). To build a healthy relationship with science children need to experience it through a permanent interaction between formal and informal learning (Burns et.al., 2003; Hofstein & Sherman, 1996).

Actually, if we enlarge the definition of Science Communication with the approach to this concept made by Burns, O'Connor and Stocklmayer (2003), we could say that Science Communication is a subset of Science Education. The authors describe the discipline as the *"use of appropriate skills, media, activities, and dialogue to produce one or more of the following personal responses to science (…): Awareness, Enjoyment, Interest, Opinion-forming, and Understanding"* (pg 183). According to this, we find that Science Communication is a discipline that provides expertise to promote dialogue between science and the public; it brings skills and activities that facilitate the work of educators with children. Science Educators and Science Communicators might come from different backgrounds (Laugksch, 1999), have a different academic training, however, in the field they work together

building the big picture of Science Education.

1.1 Science books and children

Another issue that Science Education and Science Communication share is that both disciplines produce books and most of these texts are framed inside a genre known as non-fiction.

Non-fiction books, a definition

Literature is generated from two different sources: fantasy and facts. While fiction literature has to do with the world of imagination and invented characters and events, "non-fiction" is the broad term used to define the kind of writing that is the expression and/or interpretation of observed, perceived, or recollected experience (Root, 2003). Thus, non-fiction writers do not make up stories and have to work with subjects and information that already exists.

But although the composite word "non-fiction" defines itself through the negation of fiction, there are many fact-books that make use of fiction, and also many fiction stories that have elements of fact (Fisher, 1972). Therefore, the distinction between "fiction" and "non-fiction" is not a sharp one.

However, when we focus on the definition of non-fiction books for children, we find that authors load the concept with an extra task: non-fiction books for children should also inform and instruct (Fisher, 1972; Freedman, 1992; Mallet, 1992). And this job of transferring certain knowledge should be

performed by filling the subject with imagination (Freedman, 1992) in order to clarify complex ideas and make the reader feel that he or she is participating in the discovery of this new information (Carr, 1982; Selsam, 1982).

There are different categories of non-fiction books for children, like biographies, picture books, multi subject or single subject books (Fisher, 1972) but for the purpose of this thesis, I will study them according to the interest groups that generate them[7], which will lead us to two categories: books produced within the Science Education community and those produced by the Science Communication community.

Textbooks and Trade Books

In schools, there is one sort of text that is highly used in class: the textbook (Lloyd & Nichols, 1989; Newport, 1990; Parkinson & Adendorff, 2005). By 'textbooks' I mean a standard publication for the study of a subject in a particular subject at school, which are mostly written using an expository discourse (Olson, 1980), which means they explain and describe a topic through the presentation of ideas rather than focusing on the development of actions and events.

Textbooks support the aims of the Science Education Community because they include all the contents and ideas that a child is supposed to

[7] For *interest groups* refer to heading 'Science and the Young Audience'.

learn at certain year at school - the "what to teach" concern- it also, it supports the teacher by suggesting activities to reinforce these contents -the "how to teach" concern- (Parkinson & Adendorff, 2005). Textbooks respond deeply to the "inform and instruct" definition of a non-fiction book, without worrying too much about the personal enjoyment of the reader (Graves et.al., 1988; Lloyd et.al., 1989)

Now, if we look at what sorts of books are produced within the Science Communication community, we find a different kind of text. A product that I will call "trade book": a publication edited by a commercial publisher meant for general readership. Trade books are in tune with an aesthetic approach to the content (Parkinson & Adendorff, 2005; Sutherland et.al., 2007), and to that extent these books are more interested in making the child participate actively in the reading experience (Carr, 1982; Selsam, 1982).

However, despite textbooks and trade books responding to different styles, they both interact with the same audience (young readers), and within each other, as it is a highly recommended practice to include trade books as a complement to teacher's lessons (Dagher & Ford, 2005; Sutherland et.al., 2007). So, readers will be acquiring certain knowledge through both sources.

Nevertheless, this interaction is not mirrored in the academic literature available about science books for children. When it comes to books, Science Education scholars are concerned only about textbooks and how to make their content more comprehensive (so kids can understand and remember the information they read), while Science Communication

scholars are interested in making trade books more enjoyable (so kids can perceive science as fun and related to their everyday life). So, although in 'real life' Science Education and Science Communication interact, this is not reflected in the academic literature about the books both disciplines produce. Each area focus on their own publications and this leads me to review both fields separately. The advantages of doing so are the following:

i. The creative component of this thesis is an astronomy trade book for children, which aims to be instructive and enjoyable. By reviewing how to make factual information more comprehensive (Sc. Education approach) and how to make the reading experience more engaging (Sc. Communication approach) I will collect the necessary advice to apply it to the creation of my book.

ii. Science Education has a tradition of centuries (Fyfe, 2003), and consequently has a larger volume of research in effective narratives for children. Science Communication, in turn, started growing as an academic discipline only two decades ago (Burns et.al., 2003) and the discussion about effective narratives is at a premature stage. Thus, it is advisable to look at each field in isolation, and by the end of the literature review find out how they relate to each other.

2. NON-FICTION BOOKS, THE SCIENCE EDUCATION APPROACH

Non-fiction literature for children is an area of study that has been deeply reviewed by scholars, and it is highly concentrated on textbooks. Textbooks are one of the main sources for the content covered at school and deal with most of the information and facts that students are expected to learn each year (Haggarty & Pepin, 2002). Reviewing the strategies to improve these kinds of texts will allow me to collect advice about effective ways of writing about data, which is a core component of most science topics.

Because there is not sufficient analysis about science textbooks, I will extend the scope of this review to research in reading education in general, that has explored the learning text-based strategies deeper than science educators (Guzzetti, Snyder & Glass, 1992).

2.1 Diagnosis for textbooks and possible cures

The vital role that textbooks play in the school routine is the main reason why scholars pay so much attention in trying to improve these texts (Haggarty & Pepin, 2002). Although there will not be much room for improvement if textbooks were in good health. Reality is, this kind of publication has been hardly criticized for the way they are structured and written.

Textbooks have been criticized for being loaded with too many ideas in short chapters (Lloyd et.al., 1989); showing a lack of writing style (Graves et.al., 1988); showing an emphasis on facts and generalizations (Armbruster, 1993); for the use of abstractions and for having a diminution of human agency (Swales, 1995); and also, for presenting information in an authoritarian way (Parkinson & Adendorff, 2005). In other words, they have been judged for using language in an uninspiring way, for not being able to connect with the reader through more concrete examples, for not showing the people who make new discoveries and knowledge possible, and for showing information as objective (and thus, not exposed to change).

So far, scholars have tried two ways of changing this diagnosis, and both involve using tools from creative literature to improve textbooks, like adding colourful descriptions, metaphors, analogies or stories (Negrete, 2009; Sutton, 1992) to textbooks that use mostly an expository writing style (Guzzeti et.al., 1992).

To that extent, the two most tested ways of improving the effectiveness of textbook discourse are by:

i. Adding seductive details to the text (Garner et.al., 1989, 1991; Harp & Mayer, 1997, 1998; Sanchez & Wiley, 2006; Schraw, 1998; Wade & Adams, 1990); where 'seductive detail' is considered to be highly interesting but unimportant information in relation with the core idea of the text (like an anecdote, a colourful description or an image, among others).

ii. Strengthen the connections between text ideas with the support of narrative features, like for instance conversational discourse or vivid descriptions capable of clarifying concepts (Beck et.al., 1991, 1995; Graves et.al., 1988, 1991; Vidal-Abarca & SanJose, 1998).

Seductive details

Garner, Gillinham & White (1989) adopted the term 'seductive detail' to name information in the text that is rated as interesting[8] but irrelevant to the main idea of the narration. On their first study about this issue, Garner and her colleagues (1989) conducted a series of reading experiments with adults and children to investigate the effect of the interesting yet irrelevant

[8] In subsequent research about seductive details, information could be rated as "interesting" either by the researchers or the subjects of study depending on the design of each experiment.

sentences on recall and comprehension of expository text.

For Experiment 1, they divided participants (adults) into two groups. The first one read a text with interesting-irrelevant details, and the second one read a text with uninteresting-irrelevant details. After reading, the passage participants were asked to write down the main ideas of the text (macro-processing), and also to match pictures related with the passage with certain information (micro-processing). Results showed that readers of the uninteresting-irrelevant details remembered significantly more main ideas than the other readers (macro-processing task), but showed no significant scoring in the micro-processing task. Researchers suggested that the interesting yet irrelevant details attract the attention of the readers to the detriment of the main ideas of the text.

To find how seductive detail affected comprehension in young readers, Garner et al. (1989) conducted a second experiment with seventh graders using the same reading materials as in Experiment 1. On this occasion, results showed that seductive details had a negative effect in the micro-processing task instead of the macro-processing one, as on Experiment 1. Researchers suggested that seductive details affected comprehension of different readers at different levels, and that special consideration must be placed on children, whose limited memory capacity might be occupied mostly by the distractive features after reading.

After those experiments, more researches have argued that the presence of seductive details might detract from the comprehension of

important ideas in the text. Wade & Adam (1990) studied what college students remembered from reading biographies, immediately after reading and a week after reading. Results showed that the most recalled information were seductive details (rated as low importance/ high interest) and main ideas (rated as high importance/ high interest). According to this, the researchers highlighted the importance of interest in the text information, as interesting information remained memorable for the reader even a week after reading.

On a similar approach, Harp & Mayer (1997) added entertaining but irrelevant text and illustrations to a science's textbook lesson. Their results were consistent with Garner et.al. (1989), suggesting that the seductive information captured the reader's attention away from the relevant ideas of the text. They also conducted a second experiment using the same materials of Experiment 1. The idea now was to rate how interesting were the different passages of the text in the reader's opinion. They asked the participants questions such as 'how much does this material help you to understand?' to measure cognitive value of the information; and 'how interesting is this material?' and 'how entertaining is this material?' to measure emotional value of the information. By doing so Harp & Mayer (1997) found that explanative text and illustrations (such as summary illustrations with captions) created 'cognitive interest' associated with high performance in recall of core ideas of the text; while seductive material created 'emotional interest', affecting negatively the recall of relevant information.

Up to this point, most literature claimed that seductive details showed a negative effect in learning, until Schraw (1998) suggested the contrary through a series of three experiments. On experiments 2 and 3, which dealt directly with the effect of seductive detail on recall of a biographical text (experiment 1 focused on rating interest), Scharw (1998) surprisingly found that there was a significant and positive effect between recall of seductive detail and recall of whole story, as it was reported that seductive detail helped the participants on the free recall of the total story.

Consistent with these findings, Sanchez & Wiley (2006) propose that the negative effect of seductive detail can only be partially confirmed. Their results showed that the low Working Memory Capacity (WMC) readers were especially vulnerable to the seductive detail effect, while high WMC students performed better when exposed to seductive features. Sanchez & Wiley (2006) suggest that it is the individual capacity to focus on the text and not the sole presence of the seductive information that leads to less understanding.

So far, the 'seductive detail effect' has shown to be very controversial. For instance, Ozdemir (2009) identified eight different studies dealing with the seductive detail effect in the past two decades, and only four of them could confirm the negative effect of these features; two of them partially confirmed the effect and two did not confirm it. Additionally to these conflicting results, it has been argued that some of these studies have design problems (Sadoski, 2001). In the case of Harper and Mayer's experiments for

instance, the original text was altered so much (adding almost 30% new material), that the coherence of the passage might have been altered confusing the participants on what the main idea of the text really was.

At this point, an important consideration about seductive detail must be highlighted. Apart from the negative or positive effect that seductive details might have in overall comprehension of the text, all studies have shown that the readers remember the seductive details. According to Sadoski (2001), this can be attributed to one key element of seductive details: that they are written with concrete language. A concrete style of writing means that the words used in the text evoke images to the reader; that the words bring pictures to the mind making the information memorable (Gambrell & Jawitz, 1993; Negrete, 2009; Sadoski, 2001). For instance, saying 'yesterday we experienced bad weather conditions all day' is less specific and concrete than saying 'yesterday we had rain and hail from morning until night-time'. The visual images that the verbal description brings to the mind are a powerful aid to memory (Gambrell & Jawitz, 1993; Negrete, 2009; Sadoski, 2001), and that is why seductive details are well recorded (Sadoski, 2001).

Even though the controversial results about seductive details prevent us from relying on the outcomes of the research, in terms of whether it is good or not to add seductive details to the text, we can still draw important advice from this literature.

i. **Unimportant information should always be avoided:**

All contents of a text must be carefully selected and placed. Despite the fact that the negative effect of seductive detail has not been proven, it is a constant in all studies that high interest/ low importance bits of information are well recorded. So, why would I want to fill my text with unimportant information? If I have a limited time to dialogue with the reader (through an article, a book, or a poster, for example), I want to make the most of it, and every word should count. Surely the idea of including seductive details is grounded on the idea of engaging the reader. However, different writing techniques should be used, where the relation high importance/ high interest predominates throughout the text.

ii. **Texts should be conceived as a whole piece from the beginning:** All the materials used during the reading experiments about seductive details were altered texts. I believe it is misleading to promote the idea that you can write a passage with important yet uninteresting information and afterwards garnish it with striking yet irrelevant information. The aim during the writing process should be to make the important information interesting from the beginning. It is a challenge for the writer to find a point of view from where to tell the story, or deliver the information, to find a connection

between ideas capable of linking the content together, like following the action of a character or the development of a process, for instance. Both ideas would directly address the criticism made to textbooks: the lack of human agency (Swales, 1995), and the emphasis on facts and generalizations instead of the series of actions that make knowledge possible (Armbruster, 1993).

iii. **Make the text memorable through concrete writing style:** Sadoski (2001) suggests that abstract writing -meaning language that evokes little mental images- tends to be poorly recalled in any case; and so, seductive details as concrete writing bits between abstract sentences will always be better recalled by the reader. The goal should be then to write as concretely as possible, with meaningful image evoking language for the reader, and connecting ideas with concrete explanations and/or examples that are in tune with the main idea of the passage.

Use of narrative features to strengthen connections between text ideas

After the seductive detail debate (see subheading 3.1.1) some researchers started focusing on alternative ways of accomplishing memorable expository writing. Beck, McKeon and Worthy (1995) are one of the few teams that

address directly the idea of avoiding the use of seductive detail in their experiments.

"*The task we undertake in the present study is not to add interesting pieces of information to a text, but rather to endow the core content with engaging features*" (pg 224).

Their work consisted in improving a passage from a history textbook by adding 'activity' (dynamic situations), 'orality' (dialogue and conversational tone of oral language), and 'connectivity' (highlighting relationships like drawing connections between the text and the reader, or between events and the emotional response of the agents towards those events). By working with these features, the authors were giving the text a 'voice', and created different versions of a text varying the intensity of this voice. If a voiced text engages the reader, then the students should enhance their comprehension of central content.

Beck and her colleagues worked with four versions of a text: an original passage from a textbook, a revised version for improved coherence, and a 'voiced' version of each of the two previous ones. Fourth grade students were asked to recall the passages immediately and a week after reading, and to answer open-ended questions. The results showed that, immediately after reading, students exposed to the text with both greater coherence and voice performed significantly better in recall and questions;

second best was the text improved only by coherence. One week after reading researchers obtained the same results only for the question task. For recall, no significant differences in performance were found between groups. Nevertheless, the study suggested that when engaging features of the passage are linked with an accessible presentation of ideas, they contribute to a better understanding of the text.

The importance of coherence as a comprehension predictor is a notion that has been largely studied by scholars. Texts that are distant, that do not address the reader directly, or are weak in creating relations between events detract the comprehension (Beck et.al., 1984). However, this body of research deals with texts in general (fiction and non-fiction), and by now I will to focus in those studies that approach the improvement of textbooks through usage of narrative features like colourful descriptions, orality, analogies, and so over.

On that spirit, Vidal-Abarca & SanJose (1998) reached similar results to the ones Beck et. al (1995) did. Their aim was to study the role of textual changes in comprehension, and to do so they manipulated a physics passages by (i) enhancing coherence through the improvement of relationships within text ideas (i.e. adding headings, summaries and increasing connection between ideas in the text) and (ii) inserting new content to reinforce the link between ideas in the text and the reader's knowledge (familiar descriptions that would activate the mental imagery of

the reader). Even though the researchers added extra information to the text, the focus was still on enhancing the central idea of the material and not on making the text more enjoyable by including details that in the end distracted the reader from the core meaning of the passage. The researchers created three revised versions of a text: a) high coherence, b) present linking procedures, c) high coherence plus present linking procedures, and the fourth version was the original, considered as d) low coherence/absent linking procedures.

As Beck et. al. (1995), Vidal-Abarca et. al. (1998) found that there was a positive effect on the readers' comprehension and recall only when the passage has a high level of textual coherence. Students (10th Graders) who read the 'high coherence' text performed significantly better than the rest on a test about comprehension of main ideas of the text (conducted between 2 or 3 days after reading with the possibility of using the text as a reference while answering). Also, students who read the 'high coherence plus present linking procedures' text performed significantly better on a free recall task immediately after reading. Thus, Vidal-Abarca and his associate propose that coherence in a text is the main predictor for better reading comprehension, and that other textual changes like the ones they used only work effectively when the overall text possesses a high level of coherence.

There is another series of studies that also demonstrates how certain narrative features (orality) works effectively when linked to a coherent text. In an attempt to find what makes good expository writing, Graves et.al.

(1988) worked with writers from different backgrounds to improve the quality of a history textbook. The researchers gathered three professional teams: linguists, composition instructors and editors from Time-Life magazine; they all had had the freedom to review and improve a passage of the text according to their own criteria. When they tested the passages with eleventh graders, the pieces improved by the magazine editors showed 40% more recall immediately after reading than the original textbook passages, which nearly doubled the improvements made by the other teams. The main difference between the journalists and the other experts was that they not only changed the structure of the original text, but the content, by adding anecdotes and enriching it with human drama. It looked like crafting a highly narrative text (with intensified action, use of metaphors and a sense of drama – as the journalists described their own revision) was a very successful way of improving expository text.

However, there was a problem with this study. When other research teams (Duffy et.al, 1989; Britton et.al. 1989) tried to replicate Graves's results, they ended with the opposite findings: the text reviewed by the composition instructors was significantly more effective in recall. Taking this into account, Graves replicated his own study too, finding that, in fact, composition instructor's revisions were the most effective of all, and that the proportion of recall for the students that read the magazine editors' passage was nearly 50% lower than that of the readers of the original text.

According to different experts (Graves et.al., 1991), the clue to the

composite instructor's success was the remarkable use of conversational tone, and how this helped to make the passage more vivid, with appropriate emphasis when necessary, making it a more inviting version for the reader. When the composition instructors described their own work, they said that during the revisions they had in mind six main purposes "simplifying technical information, adding background information, clarifying information, supplying transitions, emphasizing key material, and keeping the passages smooth and readable" (Graves et.al. 1988, pg 247).

What the researchers also found was that the composite instructor's version had a good amount of interesting material, defining interest-creating material as information that deals with death, danger and sex ("absolute interest") and material that includes dramatic verbs, personal (inclusive) pronouns, character identification, fast action, concrete detail, and novelty. However, their version had a lot less of these features than the magazine editor's version (a rate of .95 for the Time-Life editors versus .81 of the composition instructors), and, according to the experts[9], the proper balance of interesting information made the passage less challenging for the students, as it involved shorter paragraphs and less factual information (dates & names).

In the end, the composition instructors' version proved to be successful not only on scoring but on audience's preferences too. After conducting an attitude survey with the participants, Graves and his team (1991) reported

[9] Graves et.al (1991) includes the referees' comments of their paper review in the original article, Sadoski and Hidi (Unpublished material, 1990).

that the students rate the composition instructor's revision more enjoyable and easier to understand than the other versions.

So, in summary, expository texts that use narrative features as tools to improve their comprehension are highly memorable and at the same time arouse a positive attitude from the reader when they show:

i. **A coherent structure**: ideas are clearly organized in a macro and micro level. On a macro level the text should count with the support of appropriate chapter division, headings, subtitles or summaries when suitable (Vidal-Abarca et.al, 1998). On a micro level, the ideas presented on the text need to show how they connect within each other, signposting the causes and consequences of events (Beck et.al, 1995).

ii. **Oral language:** addressing the reader directly and making the character of a story interact through dialogue has shown to be one of the most effective features from narrative to make expository text both memorable and enjoyable (Beck et.al., 1995; Garner et.al., 1991). Approaching the reader through a conversational tone shortens the distance that could exist between the information displayed and the reader (Garner et.al, 1988).

iii. **Cautious use of lively writing**: The main characteristic of the revision developed by the team of magazine editors on Graves' et.al. study (1988, 1991) was the colourful style and vividness of the text. As the editors said, they filled the text with action and drama, which was reflected either in the language (active verbs) or the events presented (extra content and anecdotes they chose to include). However, the failure of this text version on the recall task (Britton et.al. (1989); Duffy et.al.,1989; Graves et.al., 1991) highlighted how lively writing and interest-creating material can easily turn into seductive details. However, this does not mean that the lively writing should be avoided. Lively writing should be an important consideration, yet not the 'most important' when designing textbooks (Graves et.al., 1991). Both the composite instructors and the magazine editor's version had vivid and lively material, yet the editor's piece had a bit higher proportion of it that also outstood "more than they should" (pg 118, Graves et.al., 1991).

2.2 Discussion

In this chapter, I reviewed the literature about two of the most common methods used to improve the comprehension and recall of textbooks, a type of non-fiction writing well known for the use of expository discourse (Olson, 1980) and which is highly used to deliver the contents that children are expected to learn in each subject at school (Lloyd & Nichols, 1989; Newport, 1990).

Even though the creative component of my thesis is not a textbook, I consider the revision of textbook's literature important, because they are the kind of books that deal with the problematic of delivering a high content of factual information. Science trade books also need to manage delivery of factual information, maybe not as much as textbooks, but they still do. I also believe that factual information is one of the hardest contents to communicate, owing to their dryness; thus, the advice on how to make textbooks' narrative more effective will support the writing of my creative component.

Findings

Based on the popular assumption that more lively text language can promote a better reading performance (Beck. et.al., 1995), several authors experimented on how to make texts more memorable by i) adding 'seductive details' -highly interesting but low important information- and ii) narrative features to strengthen connections between text ideas (orality, action, drama,

metaphors, among others).

Of the two methodologies, the second one has shown to be the most effective, yet only when the text itself shows a high level of coherence, making the information accessible. The use of narrative features by themselves to improve an expository passage do not show a significantly positive effect in comprehension compared to plain expository texts (Beck. et. al., 1995). According to these findings, I understand that readers need precise signpost throughout the reading to show them exactly where the text is taking them; this means that each new idea presented must be highlighted and connected with the next and previous one in a coherent chain of cause and effect.

To sustain the attention of the reader during this process, the text needs to also keep them engaged at all times with the support of information that creates high interest. Even though this might sound like an obvious statement, research in this area has shown that actually, it is very hard to find a balance between engagement and understanding of the text. Too much interest-creating material to ensure the engagement might compromise the understanding of the passage (Britton et.al. 1989; Duffy et.al, 1989; Garner et.al., 1989, 1991; Graves et.al., 1990; Harp & Mayer, 1997, 1998; Wade & Adams, 1990). Therefore, highly interesting information cannot saturate the text, and at the same time, should not be completely absent from it (Beck et.al. 1995; Graves. et.al., 1990). Some features like the use of conversational tone (addressing the reader directly, i.e. using we, you, me), concrete

language, and developing action, significantly help sustain the engagement of the reader.

All this suggests that on a scale that goes from plain texts to lively and colourful ones, the most effective writing to ensure understanding and recall is the one that can be placed just in the middle of the scale. A more lively text is not necessarily a more memorable one.

The 'Authority' issue

It has been claimed that textbooks present themselves as authorities (Parkinson & Adendorff, 2005), showing information as objective and accepted, when in fact, knowledge is changeable. Parkinson and Adendorff (2005) say that, in contrast, other publications meant for adults like papers on peer review journals or popular science articles present information as either ideas subject to confirmation or a product of people's work, with all the stress that scientific discoveries involve. This authoritative voice, where the "*writer is an expert supplying the information while the reader is a relative novice*" (pg 226, Parkinson & Adendorff, 2005), creates a distance between writer and reader.

Most of the studies I reviewed did not address the issue of 'authority' in expository writing. However, Graves et.al. (1991) do mention that the conversational tone of a passage keeps the reader closer to the text, as opposite to a more formal writing that builds an authorial distance. This reinforces the importance of 'orality' in assembling more engaging texts.

On this topic, Sutton (1992) suggests that when the writer establishes a relation with the audience, the reader comes back to the book because they like the way the writer explains or presents things. When authors are trying to *say* something to the child – as opposite for a raw transmission of information- it is more evident that there is a person behind the text, someone you can agree or disagree with.

Taking this into consideration, I believe that one of the most important things about not being authoritarian is that the author can inspire the reader to participate more actively with the information. By showing that the content displayed in the text is not static, that it changes and grows constantly, the reader could be inspired to look for more material about the subject. The authoritarian style does not leave much space for doubts; it shows the information displayed in a book as if it was all the reader needs to know about certain subject (Parkinson & Adendorff, 2005), when actually, there is much more to know than what is contained in one book. The positive effect of the conversational tone reminds us that the relation between writer and reader should be, ultimately, a horizontal dialogue between two persons.

3. NON-FICTION BOOKS, THE SCIENCE COMMUNICATION APPROACH

3.1 A young discipline

Science Communication is such a relatively new academic discipline that educational institutions around the world continue to evaluate in terms of common principles to guide their curricula. To this extent, there is still not enough accumulated knowledge and research that feed exclusively from the science communication field (Mulder et.al., 2008). Moreover, scientific literacy as a concern has been analysed much more under educational studies than from fields that disseminate science information directly to the public, for instance the mass media (Valenti & Tavana, 2005).

Non-fiction books, being a much more limited area within science communication, are given even less attention in the academic field. The publication and demand of non-fiction trade books has increased in the past 20 years (Sutherland et.al. 2007) and there are more science trade books than ever before (Stocklmayer, Gore & Bryant, 2001), however this increase does not correspond with the number of publications of academic journals. This is why, when looking at effective narratives in non-fiction books for children under the umbrella of the science communication approach, we are looking at a very narrow field of study, at least in comparison with the attention this same area has under the educational studies (see Chapter 3). Most of the

literature available in this topic from science communication studies comes in the shape of reviews, comments, or reports about how science communicators have carried on with their work as a way to transfer their practical knowledge to the community of communicators. A large amount of these works are based on personal experiences and opinions, but they lack the support from either a qualitative or quantitative research to back them up, and so, the effectiveness of the written discourse in science communication has not been examined.

In regard to popular writing on science for children, we could say that a product's effectiveness is measured according to its outreach, number of books sold or distributed, or even number of visits on a web site for an article published on the internet- in other words, measured by market criteria. Yet, the answer if whether science communicators are getting their message across to the public, or if the reader is learning something from the content displayed, has rarely been explored.

However, there is still a good amount of accumulated experience in the work of science communicators that is worth reviewing to better understand the strategies behind their creations. By taking a closer look of their opinions, I can compare their procedures with the ones already tested by the Education Scholars and see how they agree or disagree on the way to accomplish effective narratives.

Defining Science Communication

In Chapter 2, I described Science Communication using Burns et.al. (2003) definition, where the field is visualized as set of skills, products and activities capable of triggering a personal response to science involving one or more of the following: Awareness, Enjoyment, Interest, Opinion-forming and Understanding. The authors named this concept as the vowel analogy (AEIOU). I adhere to this definition because it takes into account the actions and reactions involved in a science communication initiative: it is not just the discipline that works to make science attractive or that builds dialogue between science and the public; it is defined as an activity that expects certain reactions from the public as well. If the initiative cannot provoke one of the responses expressed in AEIOU, then the science communication initiative itself fails, and thus, cannot be considered an effective science communication initiative.

I will be using the Burns et.al. (2003) definition throughout this chapter. In the future, whenever I refer to the aims or goals of Science Communication, I am looking to the purposes delineated in the AEIOU analogy.

3.2 Definitions of what makes a good Trade Book

Unlike to what I found about textbooks' literature, which focuses either on critiquing the style of these texts or on ways to improve them, trade books' literature revolves around which should be the criteria to determinate the quality of a trade book. In other words, scholars try to provide a guideline for adults on how to choose good non-fiction books for children.

Below, I will review a selection of authors that have broken down the most important features that should be present in a good quality science non-fiction book. In order to complement the scholars' perspectives, I also included the market's guidelines to select outstanding books, represented in the criteria of popular children books awards.

Carr (1982)

Carr (English teacher and author) looked at successful non-fiction books and identified a number of techniques used by science writers to keep children hooked on the story. Most of these techniques intended to dialogue directly with the reader, like the use of the pronouns 'you' and 'I', ask questions, and tell a story. She also highlighted the importance of analogies and metaphors to clarify content when new ideas were presented; and the necessity of bibliography, glossary and index to aid the reader on the scouting of the book.

On engagement, Carr mentions the use of catchy titles, vivid detail and colourful illustrations, along with clear simple sentences to make the reading flow better. Carr's outline, however, does not make a critical insight on the proper use of all these features. Her work serves as an identification of the most widely used writing features on non-fiction books, but she is not suggesting that all these characteristics should be put together in one book or if a different balance of these features could work better in the long term.

Halsey & Elliot (2007)

In order to provide a guideline for teachers that are looking for science books to incorporate in their lessons, these authors constructed an evaluation system for science trade books. They applied the criteria to a list of books recommended by publishers in order to assess their quality. Their evaluation standards considered features such as:

i. **Accuracy:** images and content presented needs to be up to date and supported by facts; information should be very clear in order to guarantee that the reader would be able to distinguish between what is fact and what is theory.
ii. **High Scientific Content:** the amount of scientific content should be substantial.
iii. **Coherence**: the book needs a logical and clear presentation of ideas.
iv. **Authorship**: author's background should be explicitly presented in the book, and his or her credentials need to be appropriate to

address the subject of the book.

Halsey & Elliot concluded that, overall, most science books have a high literary quality, which is not necessarily balanced with their scientific quality. According to the authors, one of the main characteristics that should be found in a science book for children (at least when the objective is to use it for the teaching of science) is that it should have an explicit connection to science content or processes.

Mayer (1995)

Mayer conducted a study about what young audiences learnt about whales from a children's book. She found that children had with various misconceptions after reading. As an outcome of her work, she developed a checklist of 10 questions in order to help teachers choose trade books to teach science. The guidelines as follows:

- Is the science concept recognizable?
- Is the story factual?
- Is fact discernible from fiction?
- Does the book contain misrepresentations?
- Are the illustrations accurate?
- Are characters portrayed with gender equality?
- Are animals portrayed naturally?
- Is the passage of time referenced adequately?

• Does the story promote a positive attitude towards science and technology?

• Will children read or listen to this book?

According to Rice (2002), who performed a similar reading experiment as the one executed by Mayer reaching the same conclusions, these 10 simple questions are applicable to assess the quality of either fiction or non-fiction books about science.

Wolf (1982)

The editor and reviewer Kathryn Wolf specifically deals with science non-fiction books. For her, a good book is the one that address the reader directly, and that has accuracy along with a lively writing style that is not too challenging.

Wolf developed a criterion for reviewing books, which considered the following issues:

(i) **Authorship:** whether or not the author has enough knowledge to address certain topic.

(ii) **Subject and Content:** is the subject interesting and important for the prospective reader?

(iii) **Illustrations:** are the pictures and/or drawings accurate and properly explained?

(iv) **Vocabulary:** use of proper terms related with the subject.

It is worth noticing that Wolf focuses on the author (i), the reader (ii) and the overall clarity (points iii and iv) more than on the style of the book or the different narrative features involved in the writing process. By doing that, Wolf places value on the relation between the two people that are dialoguing during the reading; paying attention to the author's skills (is the writer well prepared to communicate with a young audience on the specific topic?) as well as to the reader's interests (does the audience want/need to know about the subject?). Her concern is more about ensuring that the reader and the writer are prepared to engage on this conversation rather than to promote a colourful or lively style of writing for children.

Market criteria

If we look inside the publishing market, specifically at the selection criteria for the most renowned children's non-fiction book awards, we will find similar desirable characteristics like the ones mentioned by most authors above. Even though their guidelines are not specifically for science books, all of these awards count science themed books on their list of winners on the past years.

The New Zealand Post Book Awards for children and young adults promotes excellence in children's literature and provides recognition for the best books published annually. It establishes that a successful book should contain: accuracy of data and the current state of the knowledge; graphic excellence; appropriateness of illustrations; integration of text, graphics and

illustrations to engage interest and enhance understanding; style of language and presentation[10]. Although all these features apply to any non-fiction book, not only the ones about science, they all can fit in the larger labels of Authorship, Illustrations, and Vocabulary detected by Wolf (1982).

The Orbis Pictus Prize from the National Council of Teachers of English in the United States also looks for books that meet similar literary criteria on accuracy, organization of the content, attractive design and a style with interesting and stimulating writing[11]. Along with these standards the Children's Book Guild of Washington D.C. Non-Fiction Award adds that the lively writing and illustrations should have the capability of stimulate further pursuit of knowledge by the reader[12].

Discussion

The literature that aims to assess the quality of science trade books has a high focus on supporting science teachers who seek for literature to use in their classes. To this extent, and applying now the AEIOU analogy (Burns.et.al, 2003), 'good' science trade books are evaluated mostly by their ability to bring Opinion-forming and Understanding of scientific content (Halsey & Elliot, 2007; Mayer, 1995; Wolf, 1982). There is also a concern about ensuring that the book brings Enjoyment and Interest for the reader (Carr, 1982; Market Criteria), but it is not as prominent as the value of

[10] 2010 New Zealand Post Non Fiction Award- Additional judging criteria
[11] From http://www.ncte.org/awards/orbispictus (last accessed date 22/04/10)
[12] From http://www.childrensbookguild.org/nonfiction-award/criteria (last accessed date 22/04/10)

accurate and up to date information delivered by an author with the proper background to address the subject.

Overall, according to the authors, 'good' science books need a balance between the literary and the science standards. Nevertheless, a book that outranges the literary quality at the expense of the science is not as good as a book that works the other way round (Halsey & Elliot, 2007).

Another point that is worth highlighting is that 'storytelling', as a way of organizing the information by delivering the content as a sequence of events shaped in a story, is not mentioned explicitly as a desirable characteristic for successful non-fiction books. Carr (1982) does mention that 'telling a story' is one of the most common characteristics of successful books, yet other authors and the judging standards of literary awards do not mention it as an essential feature.

Perhaps storytelling could fit under the 'lively writing' or the 'good literary standard' label, and just to mention it in a criteria list would push the writers to follow the storytelling path playing against the variety of styles. I am not certain about the reason, yet is important to take this into consideration, as later we will see how storytelling is a largely appreciated tool for Science Communicators.

3.3 Storytelling in Science Communication

There are many different definitions of what makes up a 'story' (Stein, 1982). However, this thesis adheres to a broad definition, where story is a narration of a sequence of events involving characters whose actions are motivated by the resolution of a conflict; and thus, 'storytelling' is the action of communicating through this sort of narrative structure.

Now, the extensive use of storytelling in Science Communication is one of the distinguishing features between the way this discipline communicates with the audience and the way Science Education relates with the same audience. As stated on Chapter 2, Science Communication derives from Science Education (Negrete, 2009) and both share the same aim and public. However, both disciplines use different techniques to convey science. In the following, I will give an overview on how storytelling relates to science, and also on how storytelling has influenced the work of Science Communication.

Storytelling and Science

Science and the popularization of science are two different disciplines; the first one relies on particular techniques, methodologies and practices, and the second one avoids those and instead uses imaginative language to recreate the spirit of the scientific knowledge (Sanchez, 1998; Frias Villegas, 2008).

However, both Science and Science Communication rely on narratives to reach their audiences. According to Herrnstein Smith (1981), a narrative discourse can be described broadly as "*someone telling someone that something happened*" (pg.228). Scientific discoveries reproduced in peer-reviewed journals are special narratives for the scientific community, where findings are reported in a sequence of experiments, observations and interpretations (Myers, 1990). The way these scientific findings are disseminated to the general public, using different language and rules, end up being an alternative way of telling the same story to a different audience. In other words, the 'something that happened' is the same, but the narrator[13], the receiver and the storytelling is different in a Science Communication product.

Nevertheless, it is never quite the same story. Part of the original tale is lost in translation. This is why some scientists are concerned about the colourful language used to reach the general audience in popular science texts. Clive Sutton (1992) suggests that scientists are cautious about vivid language because the reader can be easily taken by the new imagery that colourful language brings (through metaphors, analogies, and others). Scientific language, says Sutton, aims for the opposite: not to open insights but to "*tie down the meaning of words with greater and greater precision and to make them mean one thing and only one thing –definable and fixed*" (pg. 20)

[13] Of course in some cases, when the scientist happens to be a communicator of his or her work too, the narrator on the "peer reviewed journal" and the narrator on the "popular science product" could be the same person but not necessarily the same narrator, as he or she might assume a different voice according to their audiences.

The writing style of popular science is open to the possibility of errors, distortions or simplifications, more so when it faces the challenge to write for a young audience (Dagher & Ford, 2005). One possible reason for this is that not all scientific activities fit into the storytelling frame, and the information that left out might lead to misunderstandings. For instance, Norris and his colleagues (2005) studied the possibility of using a more literary narrative (involving characters, action and event-tokens) in scientific explanations and suggested the following:

"*We have shown that narrative explanations are possible in science, but they are likely to be found in particular context, namely, those involving the explanation of unique and nonrecurring events. Since scientific work is often concerned with general and recurring events, narrative is unlikely to be found frequently or to be appropriate to the task*" (pg 558).

Therefore, when science is constrained to fit into a narrative structure that is different to its natural narrative, the original content can suffer some changes too. As Science Communication involves expressing already existing scientific information in a creative way to a general audience (Negrete, 2009), we end up with two different stories about the same original information, because the discourses of Science and Science Communication are necessarily different (Sanchez, 1998).

However, although it might look that Science Communication is

losing part of the story by leaving certain information behind, it is important to understand that the aims of this discipline are different from the aims of Science. Thereby, their narratives *need* to be different in order to provoke in the general audience reactions that the discourse of Science is incapable of, like the AEIOU reactions described by Burns et.al. (2003). For example, let us look at an important scientific breakthrough of the 20th century: the discovery and development of penicillin. When this antibiotic was discovered, the scientific community needed to know the steps that lead to its discovery, how it worked, evidence of its efficacy and how it could be produced. Yet, did the non-scientific community need to know all the chemical implications of this antibiotic? Surely not. However, the general public needed to be aware of the implications of penicillin in their lives, and how it would improve their health. To this extent, the narrative of Science Communication is extending the operating range of Science, because science and scientific discoveries affect all of us, yet not all of us are trained to access the narrative of science.

Storytelling of popular science is also able to include information that the narratives of Science misses by adapting their work to the format of academic journals, says Gallagher & Maher (2004), like the hard work or the 'happy accidents' that result in new scientific discoveries. The authors believe that this sort of information brings more perspective to the scientific work and are both inspirational and valuable as history resource. This inspirational value can be very important for popular science aimed to

young audiences, in order to enhance the scientific curiosity from an early stage.

It has also been discussed that science should be presented to the public with all its flaws and achievements in order to promote an open dialogue about this discipline in society (Locke, 1999); and the dissemination of this angle of science is in the hands of Science Communication, which has an autonomous discourse about science (Sanchez, 1998).

Influence of Storytelling in science non-fiction books

Once upon a time, science books for children were loaded with fiction. They were not 'science fiction' books, but rather the first works of non-fiction in science for a young audience. Ayleen Fyfe (2000) in her review about the first publications of this genre – starting in the eighteenth century- she tells us that all these books were fictionalized stories where the scientific instruction was fit into a narrative framework. It is clear from this that the use of storytelling is a traditional choice in the field of science trade books. Furthermore when Fyfe (2003) reports that these first science books for children were not only read by a young audience, but also by adults that were interested in learning about science, but whose level of instruction was not enough to feel comfortable reading an 'adult science book', the working class was also a frequent audience for these books.

According to Fyfe (2003), the most common features of these texts were the use of dialogue, mini-drama, or letters between children and an

adult – like a mother, father, tutor or a wise uncle. Writers believed that learning would emerge from the identification between the reader and the fictional children of the story (Fyfe, 2000).

Fyfe (2003) distinguished Kingsley among the authors that cultivated this style of writing. The use of fiction and the conversational tone is present throughout his book 'Madame Why and Lady How' (1870), which actually starts with the words "*My dear boys*". Following, an example of his writing:

"*How do I know all that? Because a fairy told it to me; a fairy who lives up here upon the moor, and indeed in most places else, if people have but eyes to see her. What is her name? I cannot tell. The best name that I can give her (and I think it must be something like her real name, because she will always answer if you call her by it patiently and reverently) is Madam How. She will come in good time, if she is called, even by a little child. And she will let us see her at her work, and, what is more, teach us to copy her*" (pg. 5).

This style of writing was also useful to accomplish one of the main goals of these first science books, which was to convey a moral lesson along with the information about the natural world, in other words, to learn and admire God's creation (Fyfe, 2003). Although the connection between science and religion decreased with time, and this was also reflected in the literature (Op.cit), the ties between science books and storytelling grew strong.

The difference is, perhaps, that nowadays there are not as many

fictionalized aspects in non-fiction for children as before. For instance, let us take a look at the winners of the New Zealand Post Award in Non-Fiction of the last decade, specifically at the texts with science themes, which reduces the list to four titles. These texts do not rely in fiction to deliver their content: they are either true stories ('E3 Call Home'[14] and 'A bird in the Hand'[15] (Hunt, 2009; 2003) or more expository texts about certain species ('Which New Zealand Spider'**[16]** (Crowe, 2007) and 'The Plight of the Penguin'[17] (Davis, 2001)). However, all these books are framed in storytelling. Hunt's books follow the stories of individual birds, native species of New Zealand and the wildlife specialists that work with them; while Crowe and Davis use a conversational style of writing -directly addressing the reader and including personal anecdotes- that reminds of the orality of storytelling.

Influence of Storytelling in training programs

When it comes to science communication, the advice of using storytelling and frame information into a narrative comes from everywhere. For instance, more than 10% of the institutions worldwide offering training programs in science communication or science writing mention explicitly the idea of developing in their students either the skill of storytelling or structuring stories and narratives from science[18]. The World Federation of Science Journalists also considers that story-telling skills are crucial to deal

[14] Awarded with the NZ Post Non-Fiction Award in 2010.
[15] Awarded with the NZ Post Non-Fiction Award in 2004.
[16] Awarded with the NZ Post Non-Fiction Award in 2008.
[17] Awarded with the NZ Post Non-Fiction Award in 2002.
[18] From research database (Davis & Hendry, unpublished data)

with the complexity of science[19]. As Jon Turney (2001) says "*every successful non-fiction writer will tell you that the way to engage the general reader is to tell a story*" (pg. 47)

In general, science popularizes agree that the use of plots as in literature is an efficient resource to create more effective communication products (Frias Villegas, 2008; Negrete, 2009); and overall science communication uses more features from literature than from the sciences to reach the public (Sanchez Mora, 1998).

Discussion

The idea of communicating science through storytelling can be traced to the very origins of science non-fiction books for children (Fyfe, 2000; 2003); this format is still popular today in the discourse of current publications for young readers.

The use of storytelling on science trade books for children is consistent with what the academic and professional community of Science Communicators advices its members: to frame science in stories. With this ongoing recommendation, we could expect that the use of storytelling will continue to perpetuate in many science communication books.

However, even though it is a common belief that storytelling enhances engagement, it is relevant to discuss if this engagement necessarily leads to

[19] During the *4th* World Conference for Science Journalists in 2004 one of the main goals of the meeting was to enhance storytelling skills. In "Goals and themes of WCFSJ2004" in http://www.wfsj.org/conferences/page.php?id=41 . Last accessed 27th May 2010.

better comprehension of the text. Most of the literature discussed up to this point relies on the idea that storytelling has the capacity to bring enjoyment to the reader (Frias Villegas, 2008; Sanchez, 1998; Sutton, 1992), an enjoyment that, ultimately, is an enjoyment of science. Even though the understanding of the scientific content still has great importance (as we will see in the subheading below), the strength of storytelling to popularize science lies in its capacity to trigger a personal response to science, like awareness, enjoyment or interest. That is why Science Communication can take the liberty of eliminating some scientific content from the original scientific narrative when it crafts a story; because the purpose of storytelling is not to translate the scientific jargon for a general reader, its motivation is to highlight the beauty of the discoveries, procedures and characters behind Science, something that the traditional narrative of Science cannot always do.

Of course, the enjoyment of Science comes together with the explanation of scientific content too, we are writing about science for non-scientists after all: writing about specific issues for a general audience requires giving content and explanations. This means that Science Communication demands from storytelling a double task: to aid the comprehension of content (important) and to produce a delightful experience based on that content (very important). Yet, is storytelling capable to live up to the expectations?

3.4 Assessing the effectiveness of Storytelling

The popularity that storytelling has reached within the Science Communication community is founded mainly in tradition, as storytelling is the oldest medium of communication (De Groot and Zwaal, 2007; Stein, 1982), and also, in the belief that narratives promote educational benefits, as they are memorable as well as enjoyable (Halkia & Mantzouridis, 2005; Klassen, 2009; Norris et.al. 2005; Negrete, 2009). However, there is not a solid base of knowledge in Science Communication to support the belief that storytelling works effectively as a mechanisms to enhance awareness, enjoyment, interest, opinion-forming or understanding of science. In other words, everything indicates that it is logical that storytelling is efficient, but few studies have been conducted to show its benefits applied to the popularization of science. In general, the attempt of Science Communication to measure how successful their products are limited to the mass media (Negrete, 2009), and little attention has been placed on other platforms of popularizing science.

This shortage of evidence is probably due to the fact that Science Communication is a relatively new academic discipline (Mulder et.al., 2008) and a more solid body of research is still a work in progress. Nevertheless, as I will report, the little research that has been done so far indicates that storytelling brings positive outcomes concerning audience engagement and understanding of a text.

Easy to read and recall

The most complete attempt to measure the ability of storytelling to communicate science, in terms of understanding and recall in the readers, was recently conducted by the Mexican Professor in Science Communication (UNAM), Aquiles Negrete (2009). He developed two reading experiments to compare the effectiveness of narrative texts and factual texts to communicate science.

The author defines 'narrative' as a way of communicating knowledge, structuring reality and organizing experience around the characteristics of action or a plot. He also uses the term narrative as synonym for story, and that is why I believe his study on 'Science Communication via narratives' also works as an evidence for the use of storytelling in Science Communication.

On Negrete's first study, undergraduate students were given two versions of two texts (a narrative and a factual version of it[20]) containing the same amount of scientific information. Four tasks were applied immediately after reading: multiple choice questions, open-ended questions, free recall of the text, and use of learnt knowledge on a hypothetical situation related to the scientific information provided in the text. The same tasks were conducted a week after reading. The idea was to measure how participants identify, remember, retell and contextualize information (quantitative measurements only).

[20] For his study Negrete used he used an adapted version of 'The Crabs take over the Island' by Anatoly Dnieprov (1968) and 'Nitrogen' by Primo Levi (1985).

Study 2 measured how information on factual and narrative texts was remembered immediately after reading, one week after and a month later. This study applied same tasks that Study 1, but it included a qualitative measure too.

Results of Study 1 showed that the 'Factual group' performed significantly better in all tasks immediately after reading. However, one week after reading, the 'Factual group' had a statistically significant decrease in performance, while the 'Narrative group' enhanced their performance, suggesting that, overall, scientific information presented in narratives is retained longer in participant's memory (Negrete, 2009).

Meanwhile, results of Study 2 showed few differences between groups in both, the 'immediately after reading' and the 'one week after reading' tasks. However, a month later both groups retained a similar amount of information, and the 'Narrative group' performed better at the retelling task than the Factual group. This implies that both the factual and the narrative texts are equally effective in conveying scientific knowledge, yet narratives are more effective in aiding the retrieving of information (Negrete, 2009).

Also, through a qualitative analysis, which aimed to identify and analyze the narrative structures used by the participants to retell the stories (narrative versions), Negrete (2009) found that the best remembered features were the ones that delivered or contained the highest amount of scientific information. In other words, characters, actions and literary resources (like metaphors, humour or dialogue) of the stories were well recorded and

quoted by the participants when they were linked to scientific information. Therefore, Negrete (2009) suggests that scientific information becomes memorable when it is linked to the development of the story, and that the more essential the scientific information is for the development of the plot, the most memorable the scientific knowledge becomes.

Negrete's studies focus mostly on the effectiveness of narratives to make scientific ideas more understandable and memorable. To that extent, his results support the idea that storytelling aids the comprehension of scientific content, which is one of the two outcomes that the Science Communication community expects from storytelling. Negrete's research did not directly address the second outcome, which is the experience of enjoyment and/or interest that science storytelling should trigger. However, another study by Halkia & Mantzouridis (2005) explored what secondary students valued from popular science articles, and found that the narrative features used in these texts enhanced comprehension, interest and the enjoyment of students.

Halkia & Mantzouridis (2005) selected a series of press science articles in order to identify the communication codes that seemed to be effective for student's science learning. The authors specifically wanted to know to what extent and why students appreciate science articles; which elements of the articles attracted the student's attention; and why students chose to read a specific article.

The 'narrative features' identified by the authors in the selected

articles were described as a style of language that expressed '*relationships of time, place, manner and action among specific, real or fictional persons and events*' (pg. 1398). Ultimately, Halkia & Mantzouridis (2005) also use the term 'narrative' as a synonym for storytelling.

The results of their exploration indicated that students prefer articles that use narrative language with lots of metaphors and analogies to introduce complex scientific concepts (Halkia & Mantzouridis, 2005). Students also viewed the narrative style as more interesting, attractive and comprehensible compared to the expository narrative of textbooks, and this motivated them to further reading.

Discussion

Based on the little evidence available, it seems that storytelling has the potential to work effectively for both better comprehension and enjoyment of scientific subjects.

Overall, Negrete's results (2009) show that both narrative and factual texts are effective to convey scientific information. Factual texts showed a better performance in short-term retention, while narrative texts appear to succeed better in the long term. Halkia & Mantzouridis (2005) also confirm that readers prefer a narrative style of writing, which is positive to enhance voluntary reading about science. Therefore, storytelling has shown the potential to accomplish both understanding of scientific ideas and engagement with the content.

Negrete's study is the first exploration about the effectiveness of science communication via narratives, and the evidence he collected during his work establishes the basis for further research in this field. Even though Negrete worked with undergraduate students for his research, which could restrain us from concluding that narratives work in the same positive ways for children, Negrete (pers.comm.) suggests that the ability to interpret and represent reality through narrative is developed at an early age, and that exposing adults to narratives is exploiting skills they developed during childhood (representing the world in a story). Therefore, narratives could work effectively for all audiences.

Still, more initiatives like Negrete (2009) and Halkia & Mantzouridis (2005) studies are needed to strengthen the advice of using storytelling. A replication of these studies, for instance, would bring valuable information to further discuss these exploratory results. One of the most valuable conclusions about this issue is the one expressed by Graves et.al. (1991), after two research teams, plus his own, were unable to replicate the results of a previous study (Graves et.al. 1988). Those results suggested that lively written texts were the most effective[21], and this was widely celebrated by journalists, historians, teachers, and text designers. However, after failing the replication Graves et.al. (1991) pointed out that empirical results are not infallible, and because of that, research about effective texts needs to complement the data with the judgment of the experts in order to guarantee

[21] For more information about this issue, see subheading 3.1.

that there are no significant differences between the collected data of one experiment and the long-term experience of the specialists.

The Science Communication's scale is still heavily loaded to the experts' judgment and has very little weight on the data side. However, it is expected that after initiatives like the ones reviewed above, the discipline will start to find a balance between both in the near future.

3.5 Guidelines from the experts (beyond storytelling)

As I have already mentioned, questions about how to produce effective texts should be addressed both from the empirical research and the expert's criteria (Graves et.al., 1991). Consistent with this idea, Sanchez (2004) noted that with so little written information available about how to conduct science communication; advice to exercise the profession should be extracted from the constant practice of science popularizes.

I have already reviewed two of the few empirical studies about using narratives to communicate science, and previously I covered how science communicators promote the use of storytelling to convey science to the general public. However, when it comes to children books, I believe it is important to know more specific advice from the experts about how to craft an effective text in terms of engaging the reader and promoting one or more of the expected outcomes of Science Communication. Moreover, most of the recommendations from children's authors revolve around subjects more varied than just the use of storytelling.

In order to illustrate this, I chose authors that have experience in communicating science to children who are also willing to share their strategies and opinions on this field. Even though there are many science communicators who work with young audiences, the availability of material about their strategies is very limited, and thus, the list of authors is limited to three. It is worth highlighting that the three writers support their work in

their own experience and observations rather than on external advice about how to address young readers.

The experts

Below, a short biography of the authors in order to show their expertise in the area of science writing for children and young readers.

Gonzalez-Espada, Wilson (2009)

Gonzalez-Espada is an associate professor of Science at Morehead State University (USA). He publishes science articles in Puerto Rican newspapers based in the idea that teachers commonly use media articles in the classroom, and thus, publishing in newspapers is a way of providing and exposing high school students to science articles of local relevance. To that extent, even though newspapers are aimed to a broad general audience, Gonzalez-Espada writes keeping in mind secondary school readers.

Massarani, Luisa (1999; 2008)

Massarani is a Brazilian science reporter. She is currently the Latin American Coordinator of SciDev.net and the head of Studies on Science Communication at the Museum of Life in Rio de Janeiro (Brazil). During the 90s she was the editor of the children's magazine 'Ciência Hoje das Crianças' (translates as 'Science Today for Children'), a publication with 200,000 monthly issues at that time, which based at least 80% of its content in

academic research (specially 'translated' onto children's language).

Penjean, Lorena (unpublished)[22]

Penjean is a Chilean journalist and screenwriter, author of the book 'El libro verde de Bodoque'[23] (2009) (translates as '*Bodoque's green book'*), a publication inspired on the science notes of an award-winning TV show, '31 Minutos' (*'31 Minutes[24]'*), and it is one of the few science non-fiction books for children written in Chile (Nunez, 2008).

The guidelines

Proximity

One of the points where the three authors agree is in developing science contents children can relate with. Massarani (1999; 2008) points out that a common problem in many children books is to present science detached from daily life. This can be seen, for instance, whenever scientists are portrayed as mad people, or untidy scientists wrapped in white coats dedicating their time to inventing things with no useful applications, or even destructive devises to end the planet. Scientific knowledge needs to be linked to activities or situations children can experiment in their everyday lives, and to understand that the people who make science is part of their community,

[22] Personal communication

[23] An online version of the book is available at http://www.conama.cl/portal/1301/article-35100.html#h2_1 (last accessed date 22/09/2010)

[24] Winner of the Iberoamerican Prix Jeunesse, category 'Best Non-Fiction Children Show' and 'Children Choice Prize', 2004.

in the same way a policeman or a teacher is.

Consistent with this idea, Lorena Penjean says that 'proximity' between the science and the child is a key element. In her book, Penjean covers 11 subjects related with Chilean environmental issues, and each theme was approached through stories most children could relate with, like an afternoon at the swimming pool (for the Ozone chapter) or an ear check (for the Noise chapter). The author says that her main concern was not to bore the audience with a patronizing teaching of science. So, the main character of the book, the rabbit journalist Bodoque, speaks with the experts in a very even way. Even though he has little knowledge about the issues that affect him (i.e. sun burns, ear pain), he is interested in finding out more. His relative ignorance is seen as an opportunity to learn, and not as a disadvantage; and moreover, by being open about his lack of knowledge, the character enhances the proximity with the young reader, who might be in the same position of 'relative ignorance' about certain topics. Actually, this way of thinking is aligned with Parkinson & Adendorff (2005) perspective: they say that one of the problems of science books for children in general (both textbooks and trade books), is that they show scientific propositions as facts, presenting themselves as an authority on the issue. Penjean's (unpublished) knows that presenting information from that point of view leaves little or no room for further exploration of the subject, and recommends avoiding the authoritative voice.

Meanwhile, Gonzalez-Espada (2009) reports that to cultivate

proximity with the reader, he chooses to write about topics that are relevant for the reader, like for instance coffee or cockfighting, which are popular subjects of Puerto Rican culture. Both Gonzalez-Espada (2009) and Massarani (1999) also strongly recommend the use of regionalisms and local traditions to reinforce the ties between science and the children's own experience with their culture.

No reader left behind

When it comes to writing for children, the question about how much scientific content you can deliver to them always emerges. However, according to Massarani (1999), this should be a concern for *all* publics and not only for kids. The author opines that children must be treated like the intelligent audience they are, and no with an exaggerated infantilism, which, says Massarani, is the common tendency when communicating science to kids. To this extent, controversial issues about science and technology also need to be discussed with the young audience (Massarani, 2008).

In addition, according to Gonzalez-Espada (2009) the text itself needs to contain all the explanations and definitions that the reader will need to understand the content, so that everyone can feel part of the intended audience.

Nevertheless, emphasizes Penjean, explanations are important, but the information displayed should also leave the reader with a need to know more about the subject. In other words, children's curiosity should never be

completely satisfied: *"To give away already digested information and show the contents as 'closed', or say that the book has all you need to know about certain topic is the worst you can do to a child. Knowledge has no boundaries and is open to growth. Children's curiosity should never be sated".*

Humour and entertainment

According to Penjean, humour and coherence were the driving engines of the writing process. Humour as a way to face new content; and coherence to make sure that one idea takes you to the next one, avoiding jumping between contents, giving an end to each story which relates to the humorous story that started the action. Gonzalez-Espada (2009) also agrees with this point of view, and highlights that the audience has warmly received humorous articles where he gives human-like characteristics to objects and animals (for example, taking Pluto to the psychiatrist after its demotion to a dwarf planet).

Meanwhile, and thanks to the feedback the readers sent through letters, Massarani (1998) learned that the articles children liked the most were the ones that allowed them to have fun with the scientific content displayed, like the ones that suggested activities and experiments the kids could perform at home or at school.

Discussion

Gonzalez-Espada, Massarani and Penjean share valuable experience about the background of writing non-fiction texts for children and young readers. It is worth noticing that most of their advice answers – without consciously proposing it– the question of what should be the aims of a successful science communication initiative.

The three authors bring different insights about how to effectively communicate science to children, but also agree in what seems to be one of the most important ideas when addressing young audiences: to show how close science is to everyday life. I can distinguish two levels of this proximity between children and science. First, we have the idea that science is present in everything that surrounds us, and second, that the people who make science are ordinary members of the community, and not members of a separate realm. Both ideas together support the fact that anyone can experience science or become a scientist. This aids to build awareness in the young audience about how science affects us, and the world we live in.

Furthermore, the use of humour mentioned by Penjean and Gonzalez-Espada (2009) certainly brings Enjoyment to the reading. From the feedback Penjean has got from the book, she knows that even younger readers[25] that still cannot get all the content from the book reread it because they find it entertaining. With respect to Massarani (1999), she knows that suggesting 'hands on' activities enhance the Interest of the reader in the contents

[25] ''El libro verde de Bodoque' was written for kids from age 10 and over. When she refers to 'younger readers' she is talking about children from 5 years old and over.

displayed, and also the enjoyment of them, as they are willing to experience voluntarily what they just read.

So far, all authors have addressed the first three vowels of the AEIOU analogy (Burns et.al., 2003). Yet, whether their strategies reach up to Opinion-forming or Understanding is a question that could only be fully answered by following up the reader with research that is beyond the scope of the authors. Nevertheless, by the way they execute their communication with the young audience, it looks like they are also heading to achieve those goals; as 'helping to put knowledge into practice' (Massarani, 1999) is a way of reinforcing learning and create an individual impression about a subject by experiencing it personally; while delivering 'provocative information' (Penjean) may lead the reader to seek for more material in a dynamic that can enhance the opinion-forming process.

In summary, even though Massarani works on the base of her personal beliefs (Massarani, 1999), Gonzalez-Espada (2009) relies on the feedback and experience given by constant publishing, and Penjean confesses that most of her work 'comes directly from the soul', all authors develop their work within the boundaries of what it is considered to be good science communication. The problem, still, is that most of this first hand experience is not systematized or peer reviewed which makes this knowledge very hard to share within the science communication community.

3.6 Discussion

The purpose of Science Communication goes beyond building a bridge between the scientific and non-scientific community; it is more than a facilitator or translator of scientific contents for the general public. Science Communication is the art of crafting the main ideas of the scientific discourse into a different speech capable of activating a whole range of responses in the audience, like awareness, enjoyment, interest, opinion-forming and understanding (Burns et.al., 2003). If the main objective of the science narrative is to inform to the scientific community about new research, the aim of Science Communication is to positively provoke the non-scientific community with this research (with either the outcomes, the process or the authors of the work).

Given that the narrative of Science and the narrative of Science Communication are different, I wanted to explore what does it takes to produce an effective Science Communication narrative, capable of triggering the reactions defined by Burns et.al. (2003). In order to do so, I reviewed the definitions of what makes a good science trade book for children, according to different experts. And later, I looked at one of the most popular advices from the Science Communication community to effectively reach the audience in terms of assuring engagement and understanding of the content: to use storytelling. Research assessing the effectiveness of storytelling was reported, and extra suggestions to reach effective narratives for children -given by children authors- were also presented.

Findings

In the previous chapter, three actors of the trade book production scene were explored: the critic, represented by the reviewers of science trade books; the Science Communication community, which trains new communicators and produce critical thinking about the discipline; and the authors of science non-fiction texts for young audiences. Only the latter, the authors, actually write the books or texts; however, the three actors have an opinion about how these texts should be written. Interestingly, none of them seem to completely agree among themselves about what is the most important feature to accomplish an effective style of writing about science to children.

Reviewers stress the importance of accuracy of the scientific content (Wolf, 1982), highlighting that even though it should be a balance between literary quality of the text and the science displayed, it is better when the scale inclines to the science more than to the literary features (Halsey & Elliot, 2007; Mayer, 1995). Therefore, the most valuable outcome from science trade books should be the Understanding and Opinion-forming, and the effectiveness of their narratives is evaluated according to this criteria.

However, for the Science Communication community, the Enjoyment of the scientific content displayed in the text is the most important element. Thus, it is a widely recommend advice to use storytelling to communicate science (Turney, 2001). It is believed that storytelling can enhance both, Understanding and Enjoyment (Frias Villegas, 2008; Fyfe, 2003; Negrete,

2009; Sanchez Mora, 1998), and even though not much research has been conducted to demonstrate this, the few studies conducted in this direction show that storytelling has the potential to do just that (Halkia & Mantzouridis, 2005; Negrete, 2009).

When it comes to the authors, the most important issue is not the style or the way the content is delivered, but the way that content is portrayed: authors are more concerned about how science, scientists and scientific contents are described in relation to the child, more than about what style of writing is being used. In other words, authors make a clear statement, which is: science is part of everyone's life and can be developed by anyone that follows the proper training or study to do so. To that extent, creating Awareness of how science affects the community as a whole is the most valuable outcome of a science text. Therefore, the effectiveness of its narrative should be measured according to how good is the text in creating proximity between the reader and the science (Gonzalez-Espada, 2009; Massarani, 1999, 2008; Penjean, unpublished). Still, the Enjoyment of the text is an important issue, and this is accomplished by giving proper explanations of content when needed, so that everyone can feel part of the intended audience (Gonzalez-Espada, 2009); by using humour (Gonzalez-Espada, 2009; Penjean, unpublished); and by motivating the reader to further activities related with the content of the text (Massarani, 1999).

A point in common with the reviewers of science trade books is that authors also do not explicitly advise the use of storytelling. Then, the open

confidence in storytelling by the Science Communication discipline deserves a second thought. Where does it come from? Thanks to Fyfe's (2003) review of the first science books for children –also read by adults from the working class- we know that historically these sort of texts where crafted with a mixture of storytelling and science. But, is tradition the only reason to promote its use? More provable than this, is that Science Communication is mirroring findings on the Science Education field, where the 'lively style of writing' (which is not exactly the same as storytelling, but also deals with characters and developing action) was largely tested and discussed[26].

Actually, Negrete (2009) supports his advice on the Science Education previous experience with testing effective narratives, yet most of the Science Communication advice makes no reference to this, and therefore, they do not take into account the precautions that this style of writing requires; or at least they are not communicating the pros and cons of it, as the recommendation only deals with the positive potential of storytelling. Therefore, it is necessary to take the 'storytelling advice' together with the findings of Science Education within this same area to properly balance the potential of this discourse in the area of communicating science.

In Summary, the views of the three different actors *together* bring a comprehensive approach to how to write effective texts for children that taken on their own would not be as enlightening as the sum of the parts. The three views together give advice about the issues that should be taken care of

[26] For more information on this issue, refer to Chapter 3.

in order to accomplish the five expected outcomes of Science Communication: Awareness (authors view), Enjoyment (Science Communication approach); Interest (authors), Opinion-forming (reviewers criteria) and Understanding (all actors).

4. CONCLUSION

From the previous literature review, it is clear that there are various aspects of writing -developed by experts from different backgrounds- that influence the acquisition of an effective text. Gathering all these different perspectives together aided the process of writing the Creative Component of this thesis (see Chapter 5). As the author of this thesis, I will now take a more personal approach to the conclusions of this review, as they affected directly my own creative process for writing the children's book **Look Up!**.

Reviewing the different advices on effective narratives specifically helped me to become conscious about the decisions I took while writing my children's book. In the words of Jon Turney (2001):

"*Introducing a set of new things to consider may ease the path for some people, inhibit others. But there is one general truth about learning to write which speaks in their favour. Any piece of writing is the product of innumerable individual decisions, of numerous different kinds. The effective writer has gone through a long process of becoming conscious of those decisions. But that consciousness requires a way of describing what the various kinds of decisions are*" (Pg 61).

Discussing both the Science Education and the Science Communication propositions to effective writing of science enlarged my own experience on the subject, enriching that 'long process of becoming conscious' described by Turney (2001). Evidently, that process has not

reached an end, and will continue to progress with the exercise of my profession. However, as a starting point, I developed a set of questions based on the recommendations of the literature review, which I applied to the writing of my creative component. This checklist was made in the same spirit that the one developed by Mayer (1995) in order to aid teachers to choose 'good trade books' for the science class; yet my list aims to help the author of the book to think about the decisions made during the writing process of the book. For instance, I had to rewrite my book several times in order to match the text according to the propositions of this questionnaire, firmly believing that by guiding the editing process with this checklist I would achieve a more effective text. As follows, the checklist goes along with the evidence or information that supports the existence of each question.

The checklist

1. Is the text written with a language that evokes mental images?

The use of 'concrete writing', a language that creates vivid representations in the mind of the reader, is so far one of the best predictors for recall of a text (Gambrell & Jawitz, 1993; Negrete, 2009; Sadoski, 2001). In addition, all research on the 'seductive detail effect' supports this idea. Even though the studies conducted to prove the 'seductive detail effect' were not testing directly the concrete style of writing, all seductive details used in the examinations were passages of concrete writing (Sadoski, 2001), and all of them were well recorded by the reader (Garner et.al., 1989, 1991; Harp &

Mayer, 1997, 1998; Sanchez & Wiley, 2006; Schraw, 1998; Wade & Adams, 1990). Thus, a proper concrete language –this is, 'important information' in concrete style and not 'irrelevant information' as seductive details are defined- enhances recall. (For more information on 'seductive details' see subheading 2.1).

2. If the text includes anecdotes, facts and details, are they related to the key concepts of the book?

The concrete style of writing can easily lead to the proliferation of seductive details (Garner et.al. 1991). So, a cautious inspection of the lively writing is needed in order to keep the focus in the main ideas of the book.

3. Are the ideas of the text related to each other in a coherent way?

Concrete language on its own is not as effective as concrete language along with a coherent structure (Beck et.al, 1995; Vidal-Abarca et.al, 1998). The text needs to reveal an explicit connection between ideas and events in order make clear how each idea relates with the previous one and the following ones (Beck et.al, 1995).

4. If using storytelling to communicate science, is the story related to the scientific content and/or aiding the introduction of new scientific concepts?

The use of storytelling is a popular advice within science

communicators (Turney, 2001). However, to ensure the positive outcomes of it and to protect the coherence of the text, the story needs to be connected to the scientific content (Negrete, 2009); if not, storytelling turns into an attractive but distracting hook that engages the reader, but unfortunately ends up being more understandable and memorable than the scientific information the author wants to communicate. If the story is not connected to the science, then storytelling turns into an enlarged version of a seductive detail.

Moreover, storytelling and the narrative language associated to it motivate the audience to further reading on the subject (Halkia & Mantzouridis, 2005). Thus, a tighter link between storytelling and the scientific content promotes a better engagement and creates interest about the science that is being communicated.

5. Is the text building a connection between the scientific contents and the reader?

Showing the reader that the science involved in the text is related to his or her life is the main concern mentioned by children authors (Gonzalez-Espada, 2009; Massarani, 1999, 2008; Penjean, unpublished). To that extent, it is important to be explicit about *how* or *why* the science or the scientists of the text influence the child's world. Considering this helps to promote scientific awareness in the young audience.

Furthermore, highlighting these connections between content and

reader is one of the primary tasks of Science Communication. Being able to show how science affects everything and everyone is an idea that the narrative of Science by itself does not necessarily do. Thereby, the narrative of Science Communication is expected to fulfil that role, going beyond the mere presentation of scientific information.

6. Is the text presenting scientific propositions as facts? (If yes, consider rewriting)

A scientific proposition is understood here as a provisionally accepted hypothesis, an idea that the scientific community has not yet agreed to consider a fact. Thereby, texts addressing these issues should acknowledge the subject is a matter of debate and not a fact

This is the only question of the checklist that should not be ticked. A case were 'no' is the correct answer. Parkinson & Adendorff (2005) reported that most science books for children displayed information from an authoritative perspective, to that extent; texts are suggesting that the information displayed in a book is all the reader needs to know about certain subject. If the text avoids the authoritative voice, and in contrasts, shows how knowledge is changing and expanding constantly, it is more likely that the reader will be inspired to find out more about the subject (Penjean, unpublished), enhancing his or her interest, curiosity and opinion-forming process.

Also, sharing with the young audience that sometimes scientists face

controversies and discussions is one of Science Communication's duties (Massarani, 2008), and a way to ensure that young readers are treated as a respectful audience, capable of participating in ongoing debates by building their own opinion about the subject.

7. Is the author suggesting how to further explore the contents displayed in the text?

This question is on the same track as number 6. However, this one aims to make sure that the reader is encouraged to look for more information. For example, a suggestion of related books, web sites or movies, or any source that might help to enrich their knowledge about a topic. By providing this sort of information, the author is encouraging the idea that there is always more to know about each subject.

8. Does the book show the people and processes involved in the scientific content?

Showing people and processes involved in making science is a way of reinforcing some ideas already reviewed in previous questions. This illustrates that to strengthen compliance of an idea we need to count with the aid of different elements throughout the text. Specifically, showing individuals and the course of actions involved in the development of science will highlight that science is a work in progress, led by ordinary people that do extraordinary hard work to find new discoveries. This is another way of

enhancing the 'proximity' factor, as it shows that everyone can get involved in science with the proper training (Massarani, 1999). It also strengthens the accuracy of the science, as revealing people and processes help to make a distinction between which issues are still being debated within the scientific community and what sort of knowledge is accepted already as facts (Halsey and Elliot, 2007).

All this adds up to create a more accurate idea on how the scientific community works and who is part of it, i.e. common people and not mad scientists (Massarani, 1999). To that extent, it helps to create awareness, opinion forming and understanding of the scientific discipline, and even enjoyment and interest if the reader gets really engaged with the activities and people that have been portrayed in the text; and this is precisely what Science Communication aim for.

9. Is the narrator talking directly to the reader and/or using dialogue?

In both the Science Education and the Science Communication community, orality has shown to be an effective feature to enhance comprehension and enjoyment of the text. The use of dialogue and a narrator that uses the worlds 'you', 'me', 'us', or 'we' have a positive effect on the reader (Beck et.al., 1995; Garner et.al., 1988, 1991) and an even stronger effect when this orality goes together with a coherent text (Beck, 1995); something already mentioned in question 3. Moreover, orality has been used since the first popular science books for children (Fyfe, 2000, 2003) and is still a

popular feature in awarded modern publications (see Chapter 3, subheading 'Influence of Storytelling in science non-fiction books'). Orality is also an important feature within storytelling, which is also suggested to be an effective way of communicating science (Halkia & Mantzouridis, 2005; Negrete, 2009).

10. Does the book include the sources of the content or the credentials of the author to address the topic?

One important issue for book reviewers was if the author had the appropriate background to address a topic (Halsey & Elliot, 2007; Wolf, 1982). Having a background in the subject means either that the author has an expertise on the topic he or she is writing about, or that the author has conducted proper research about this topic (Penjean, unpublished). In any case, revealing the sources of the work ensures the reader knows were the knowledge comes from, and somehow, challenges the 'authoritative' voice, as the author is acknowledging the content is based on previous work (either comes from studying the subject, or from field work or from research, or all of them together). The knowledge does not start and end with the author; it is part of a continuous series of elements passing onto each other until they reach the book, and ultimately, the reader who con also feel part of that process if he or she chooses to learn more about it in the future.

Final words

The above checklist is not meant to be a prescription or a recipe to write effective science books for children. It represents a guideline that, at least, eased my own path to approach a more effective narrative.

The considerations represented in this checklist are based on limited research about effective narratives; further explorations are needed especially in the area of Science Communication. This would complement the larger body of work developed in the Science Education discipline (which has a high focus on recall of information) bringing a more comprehensive understanding about communicating science via storytelling which has already shown to be a very promising field for enhancing both understanding and enjoyment of texts.

CREATIVE COMPONENT

5. THE BOOK

"'And what is the use of a book', thought Alice,
'without pictures or conversations?'"
Alice Adventures in Wonderland
Lewis Carroll

Thousands of years have passed since the first native people of Chile started to observe the heavens to look for orientation, seasonal timing and advice to design calendars. Nowadays, we have replaced the naked eye by million dollar technologies to observe the sky; and the cosmos is no longer a source to find out about the near future, but an open canvas to explore the origins of our universe.

LOOK UP! is a non-fiction picture book for children from ages seven and up, that aims to portray the development of the astronomical science in Chile, showing the high-tech instruments and the people that work with them, and at the same time, acknowledge the ancestral background of the territory where most of these telescopes are located.

LOOK UP! is about the six biggest astronomical observatories located in the north of Chile (Paranal, ALMA, Las Campanas, Tololo, Gemini and La Silla). Following the journey of the aboriginal constellation Yakana, a llama that was believed to descend to Earth to drink water (Berenguer & Martinez, 1986), the reader will travel through the Atacama Desert getting to know each astronomical operation. The book will show where the observatories are, how astronomers work there, and which sort of discoveries the

telescopes are capable of achieving.

5.1 Why this book?

Currently there is not enough written material to promote astronomy to a general public in Chile. The main big effort that has been done lately is a collection of four titles published in 2008[27], aimed for a general audience with a special focus in high school students.

During the International Year of Astronomy (IYA) in 2009, several efforts were made to promote astronomy in Chile. With the aim to disseminate, educate, motivate, and attract the Chilean society to astronomy[28], the Chilean node of IYA conducted activities like seminars, open tours to observatories, talks for primary and high school students, concerts, plays and art exhibitions related with this science. However, few publications for children remain after this big international celebration. One material that can still be accessed on line is an activity booklet[29] dedicated to astronomy edited by Explora, the National Program of Non-Formal Education in Science and Technology of Chile. This material suggests interesting activities for children, like calculating the distance between planets and games to learn more about celestial objects, but it does not have an emphasis in the advantages of Chile for the development of astronomy. Given this scenario, there is a clear need to produce more materials for the

[27] Ruiz, M.T, "Hijos de las Estrellas" (Children of the stars); Barrientos & Lopez, "Con ojos de gigante" (With giant's eyes); Hamuy & Maza, "Supernovas"; Minniti, D, "Mundos Lejanos" (Distant worlds). Ediciones B.

[28] Vision and Objectives of the Chilean node of the International Year of Astronomy 2009. Available in http://www.astronomia2009.cl/vision-y-metas (last accessed date 29/06/2010)

[29] A Spanish version of this publication can be accessed in http://www.explora.cl/index.php?option=com_content&view=article&id=73:publicaciones&catid=60:publicaciones&Itemid=129 (last accesses date 29/062010)

popularization of astronomy en Chile.

Moreover, on 2008, the National Commission on Science and Technology of Chile (Conicyt) awarded me a scholarship[30] to fulfil the master in Science Communication at the University of Otago with the project of a children non-fiction book about the observatories, acknowledging the lack of written sources about astronomy in Chile.

LOOK UP! will help to fill a gap of information about this subject, leaving the message that astronomy –as any science- is an open world for anyone, and even more for future Chilean scientists.

[30] Becas Bicentenario de Magister en Nueva Zelanda (Bicentennial Scholarship for a Master in New Zealand). http://www.conicyt.cl/573/article-30636.html (Last access date 08/10/10)

5.2 Narrative

The style of writing used in this book was based on the many considerations that arose as a result of the Literature Review from the Academic Component of this thesis. For the Conclusions of this Academic Component, I developed a 10-question checklist that can be applied to science texts for children in order to enhance their effectiveness in communicating science. As a way of making explicit how the Academic Component informed the Creative Component, I will illustrate with concrete examples how the book answers to each question.

1. Is the text written with a language that evokes mental images?

Yes. The language used in the book intends to describe as concrete as possible the natural landscape where observatories are located (the Atacama Desert) and the activities the astronomers perform in the observatories. The idea is that the language used in the book creates mental images that enhance the book's illustrations. For example, to describe the desert the text says: "*The Atacama Desert is an ocean of dust and rocks; of plains, mountains and cliffs*". To describe what the job of an astronomer is, to measure celestial bodies in the universe: "*They are the people hunting for objects in the sky: stars, planets, galaxies and more. They watch to find how big or small; how hot or cold; how new or old these things can be*".

2. If the text includes anecdotes, facts and details, are they related to the key concepts of the book?

To answer this question, the author needs to know exactly which are the key concepts of the book, which are the main ideas of the text. **Look Up**! aims to communicate that (i) the north of Chile hosts many different big astronomical observatories, (ii) that the observatories were built in the north of Chile because the desert offers very special natural conditions for them, (iii) that to have many big observatories in one place is something very unique in the world, (iv) and that astronomers use the observatories to watch the universe.

Look Up! does not include anecdotes, basically because they did not fit into the style of the book. I believe anecdotes fit well in a relaxed conversational pace, when there is a lot of time available to talk. The premise of **Look Up!** is to follow a creature through the desert, being very careful not to lose her from sight: there is no time for distended conversations.

However, the book does have details and facts that help to build the story. Most details are included to make the reading experience more vivid, in order to better experience the situations described in the book. For example, let us look the following paragraph:

"Are you tired? ***It is quite hard to breathe at these heights; there is little oxygen at the top of the mountains****. We are travelling through places so difficult to reach, that even astronomers prefer to watch the sky without leaving the city".*

The highlighted sentence represents a detail and also a fact: the lack of oxygen over 2,000 meters, were most observatories are located (over 4,000 most of them) makes breathing difficult, and you get easily tired because of this. This detail gives a better perception of the places the book is talking about, and at the same time, links with the next information of the paragraph: that because of the extreme natural conditions of these places, most astronomers do not visit the observatories. This passage reinforces one of the main ideas of the text, which is that 'the astronomers use the observatories to watch the universe', describing one of the ways in which these scientists interact with the telescopes. This sentence also intensifies the special natural conditions of the desert's mountains. So, this initial detail about how difficult it is to breathe is connected to key concepts of the text.

3. Are the ideas of the text related to each other in a coherent way?

The text of **Look Up!** can be divided in 13 passages, and each of them is connected in a logical sequence. The identified passages are the following:

(i) Narrator invites the reader to walk in the desert and specifically to look at the night sky.

(ii) A constellation (Yakana) descends to earth, and the Narrator asks the reader to follow her with the promise that she will lead us to special spots of the desert.

(iii) Yakana reaches the first of these special places: Chajnantor, where astronomers gather to explore the universe. Here, the narrator

explains what an 'astronomer' is.

(iv) Narrator tells that astronomers use 'telescopes' to observe the sky, and explains what a telescope is, and that telescopes need special places to work properly.

(v) The Narrator introduces the basic conditions telescopes need to work well, and reveals that the Atacama Desert meets all this conditions. Hence, the Atacama Desert hosts many telescopes.

(vi) Yakana keeps her way and the Narrator invites the reader to continue the journey in order to visit the world's most modern observatory: Paranal.

(vii) Once in Paranal, the Narrator describes the basic steps of the astronomer's routine, starting with the observation night and finishing with the publication of a discovery.

(viii) The narrator invites the reader to see the next observatory, Las Campanas and highlights that it is hard to access the observatories, because they are set in remote locations. That is why most astronomers do not visit them and access them through the computers. The visit in Las Campanas is over and the walk continues.

(ix) On the way to the next observatory the Narrator suggest the reader to look up to the sky again in order to observe some astronomical phenomena that can only be seen from the southern skies.

(x) It is because the southern skies offer phenomena that cannot be seen from the northern hemisphere that some observatories came to set in the north of Chile, like the Gemini Observatory.

(xi) The Narrator announces the journey is going to end soon and hopes Yakana will not return to the sky before we get to see the last observatories.

(xii) We reach the last two spots, Tololo and La Silla, which were the first observatories ever built in the north of Chile. The Narrator announces that soon more telescopes (bigger telescopes) are going to be built in the desert.

(xiii) The narrator says goodbye and invites the reader to come back again, because there are plenty of things to discover in the universe.

Each event in this sequence is connected to the previous and the subsequent information. It is true also that some passages of the text need to be linked together by the invitation to keep walking, and the walking action might not be related directly with the information that has just been given, for example between passage v and vi. However, the book relies under the premise that for one night the reader will walk through the desert in order to see amazing places. Therefore, the invitation to keep on moving to learn from new places is coherent with the main idea of the story.

4. If using storytelling to communicate science, is the story related to the scientific content and/or aiding the introduction of new scientific concepts?

Look Up! uses a story to give a connection between the different observatories that are in the desert. There are not many things that link these observatories together in 'real life' apart from the fact that they are all used for astronomical purposes and that they are all in the north of Chile. Apart from that, we could say they all belong to different countries, use different technology and search for different things in the sky. To storytelling used in the book is an invitation to undertake a journey following a mythological creature, Yakana, who will show us amazing places: the observatories. To that extent, this fictional character helps to introduce these places where astronomical science is developed. She literally helps the reader to get to these places.

However, the one in charge of introducing the scientific information of the text is not Yakana, but the Narrator. And the Narrator is a crucial part of the storytelling in the book, as she delivers the story in first person, and furthermore, she also walks through the desert with the reader, becoming a character in the story.

In summary, the elements of storytelling in the book are features that support directly the delivery of the science in the book.

5. Is the text building a connection between the scientific contents and the reader?

Along with the study of dinosaurs, astronomy is one of the sciences that are more detached from our everyday life. In Quintana & Salina's (2004) words: *"Nothing can be socially less relevant than dinosaurs and cosmology"* (pg 53). However, the authors acknowledge that these two issues are the ones that intrigues people the most, because they are subjects related to the study of our origins. To this extent, it is hard to draw connections between astronomy and everyday life. However, the book appeals to this natural curiosity for the universe from the very beginning, starting with the title: Look Up! Because to look up at the sky is something most of us can and like to do.

Appealing to this natural curiosity for the heavens is a way to connect astronomy with the reader. The text suggests that we look at the sky with our eyes, but when people become astronomers, they can look at the sky with giant eyes (the telescopes).

The text also asks the reader to adopt the astronomer's position. For example, when it says "*Moving skies make stars twinkle, steady skies make stars still. And if you wanted to photograph the night sky, what would you say? "Stay still!"* Furthermore, it invites the reader to consider the possibility of becoming an astronomer at the end of the story.

In conclusion, the text builds connections with the readers by reminding them that the night sky is up there for us to enjoy all the time (you

just need to get far away from the city lights), and that anyone who proposes it can explore the universe more deeply by becoming an astronomer.

6. Is the text presenting scientific propositions as facts? (If yes, consider rewriting)

Look Up! Does not rely on scientific propositions (this is, as described in the Conclusion Chapter, provisionally accepted hypothesis). If anything, the text reinforces the idea that there are still many things to discover in the universe.

7. Is the author suggesting how to further explore the contents displayed in the text?

Indeed, at the back of the book there is an invitation to find out more about the observatories, giving a list of websites where the reader can find information, pictures, and videos.

8. Does the book show the people and processes involved in the scientific content?

Look Up! aims to strengthen the idea that astronomy is a science that requires team work. In consequence, the illustrations show astronomers working in pairs or groups. Actually, the people in the illustrations are based on real people working in the observatories. They are not exact representations and they do not intend to depict specific characters;

however, the illustrator based his drawings on images and videos selected by the author in order to keep a sense of reality.

In respect to the processes, as mentioned in question 3, the book describes the basic steps of the astronomer's routine and also, the way astronomers interact with telescopes.

9. Is the narrator talking directly to the reader and/or using dialogue?

The oral narration is a central feature of the book. The Narrator speaks in first person and address the reader directly by using the words 'you', 'me', and 'us'; and also by making open-ended questions to the reader.

10. Does the book include the sources of the content or the credentials of the author to address the topic?

At the end of the book there is a series of author's notes. One of them specifically reveals that the author is a writer that gathered all the information of the book by talking with experts, visiting and reading about the observatories. Some of these sources are part of the suggested sources the reader can use to further explore the subject too.

5.3 Visual style

The format I have chosen to develop my creative component is the picture book. In this kind of books, images and words tell the story together. Here images not only stand for an aesthetic appreciation; they exist primarily to assist the storytelling and communicate information (Nodelman, 1988) through a complex interaction between images and text (Nikolajeva & Scott, 2000).

The reason for choosing this style of books is mainly because it broadens the audience range: the dynamic between images and words allows different levels of interpretation for sophisticated and unsophisticated readers (Nikolajeva & Scott, 2000). Even though the age range of **LOOK UP!** is for seven years old and up, the nature of picture books give even younger readers the chance to explore the stories, as smaller children can decode the narrative of images earlier than they learn to read (Nodelman, 1988). And so, picture books provide a more inclusive approach for all audiences. Because even though it is important to keep the age target in focus, the more people that can enjoy the book, the better.

Illustrations

The pictorial style used in the books is a mix of watercolour drawings and photographic collage. All the human and animal characters of the stories will be depicted in drawings, while most of the astronomical observatories

will be presented in real photographs. As Nodelman (1988) suggests, from all the ways and techniques to depict things, photographs represent reality more accurately. By using both photographic images and hand-drawings, we are also communicating that the story uses elements of both fiction and non-fiction: the characters that appear in the book are based on real people but in the end, they are fictional characters; the observatories are real and according to that, they are represented in the book with the most reliable visual image possible.

The illustrations of **LOOK UP!** were created by the Chilean artist Leonardo Rios, and were based on a detailed script that was written by the author of the book along with the text of the stories. The photographs used to create the collages are courtesy of the European Southern Observatory, Gemini Observatory, Las Campanas Observatory Carnegie Institution of Washington, and the National Optical Astronomy Observatory.

5.4 Language

For the purpose if this thesis, LOOK UP! will be presented in English. However, a Spanish version of the book will be produced in order to reach the target audience: Chilean children. The Spanish translation for the book's text is available in the Appendix of this thesis.

5.5 Sources

I have a background in journalism, and my only connection to astronomy before I started to write **LOOK UP!** was writing a couple of articles about Chilean astronomers and Project ALMA[31] for a science magazine[32].

In order to collect the essential information to write my creative component, I researched the field of giant telescopes in the north of Chile by visiting a state of the art observatory in Chile under construction (ALMA), and, of course, reading and watching the most relevant information about telescopes that was available for general public.

Field visits

ALMA

In October 2009 I visited Project ALMA, in San Pedro de Atacama, Chile. I had the opportunity to stay at the site camp for two days, where all the scientists, technicians and administration personnel live and work; after a medical examination, I was allowed to ascend to the Plains of Chajnantor (5000 m), where the antennas are set[33].

During my visit, I was accompanied by Valeria Foncea, the European

[31] ALMA: The Atacama Large Millimeter/sub millimeter Array is a radio astronomy observatory set in the Atacama Desert.
[32] The magazine was 'Revista FCFM', a publication from the Faculty of Physics and Mathematical Sciences of the University of Chile, intended for an adult general reader.
[33] The ALMA array will be composed of up to 80 antennas. The Observatory is expected to be start running during 2013. At the time of my visit, two antennas were already at the plains and five more were being tested at the camp.

Southern Observatory (ESO[34]) Press Officer; who gave me access to all the facilities of both the camp and the observatory itself. Thanks to that, I was able to experience first-hand how the staff worked, solved problems and relaxed after shifts; I could see an antenna from the inside, observational data entering the computers in real time, and the stunning natural environment where the observatory is set. Moreover, I experienced the challenge of working in the mountain heights: the temperature oscillation, the dehydration, and the memory gaps produced by the lack of oxygen.

After spending two days in the observatory, I built a valuable relationship with the people that worked there, which enabled me to freely contact them in the future for further enquires about astronomy and telescopes in general.

Cerro Calan

The National Observatory Cerro Calan is set in Santiago (Chile). It currently holds historic telescopes and domes, together with modern telescopes aimed at both teaching and popularizing astronomy. The observatory hosts undergraduate and postgraduate programs of astronomy carried by the University of Chile.

Owing to my work as a science journalist, I visited Cerro Calan in several occasions between 2007 and 2009. There, I had the opportunity to experience a more historical approach to the observatories in Chile, hold informal conversations with many astronomers, and visit the small museum

[34] ALMA is a partnership of Europe, North America and East Asia in Cooperation with the Republic of Chile. ESO is the European partner in ALMA.

where historic instruments are exhibited.

Atacama Desert

As the Atacama Desert is an important character of **LOOK UP!** I believed it was important to have a proper knowledge of the place. Together with visiting ALMA, during October 2009 I also spent four days in different locations in the desert, in order to take pictures and to collect information about the flora and fauna of the region. I had also had a previous experience visiting this place and some other natural locations that are present in the book too (like the Coastal Mountain Range of Chile). All this knowledge aided the process of writing and illustrating the book, as it allowed me to give complete material and guidelines for the illustrator to follow.

APPENDIX

Spanish translation for 'Look Up!'

¡Mira ahí arriba!
Por Sofía Otero C.
Ilustrado por Leo Ríos M.

El Desierto de Atacama está en el norte de Chile. Es el territorio más seco del mundo, porque solo llueve cada 10 años o más. Esta es la historia de personas y lugares increíbles que tú puedes encontrar en este desierto. Personas y lugares que te llevaran fuera de este mundo.
Y a pesar de que esta historia es producto de mi imaginación, también es muy cierta.

Pg.3
Esta noche, te invito a caminar conmigo por el Desierto de Atacama.

Pg.4
El Desierto de Atacama es un océano de polvo y rocas; de pampas, montañas y quebradas. No hay caminos para seguir, así es que no te separes de mi. ¡Ven! Siente como el polvo se levanta a cada paso; salta sobre los cristales de sal que se asoman desde el suelo. Y lo más importante de todo: ¡mira ahí arriba! Por sobre las montanas, mira ahí arriba, a la noche más hermosa de la Tierra.

Pg.7
Las noches en el desierto son inmensas, oscuras, y llenas de estrellas. La noche nos rodea. Ella cubre este paisaje de lado a lado, y sus estrellas brillan tan fuerte, que su luz es capaz de proyectar tu sombra en el piso.
Noches como esta me hacen pensar en lo bueno que es el universo para guardar secretos: ante nuestros ojos parece muy quieto, pero en verdad, ¡el

universo cambia y se mueve muchísimo! ¿Viste eso? Mira con mucha atención a la Vía Láctea…

Pg.8
Ahí arriba hay un camino, un camino habitado por animales hechos de oscuridad y estrellas. Uno de estos animales esta bajando. Es Yakana, la llama. Todas las noches Yakana deja a su cría durmiendo en el cielo y luego baja a la Tierra a beber agua de los manantiales.

Pg.9
Cuando ella empiece a caminar, ¡no la pierdas de vista! De ahora en adelante la vamos a seguir.

Pg.10
Yakana conoce muy bien este deserto porque lo ha visto desde arriba; ella conoce muy bien este desierto porque siempre camina por él. Sigamos a Yakana, pero sin molestarla, o de lo contrario desaparecerá, y tú y yo estaremos perdidos.

Pg.11
Caminemos junto a Yakana, despacio, sin que nos note. Junto a ella, encontraremos lugares del desierto donde el cielo se siente más cerca de la tierra. Caminemos junto a ella y descubriremos lugares donde la gente se junta a descifrar los secretos del universo.

Pg.12
Lugares como Chajnantor.

Pg.14

En las alturas de Chajnantor, algunas personas miran el cielo con mucho cuidado, ellos son los astrónomos y astrónomas. Ellos son las personas que cazan objetos en el cielo: estrellas, planetas, galaxias y más.

Pg.15
Ellos miran para aprender que tan grandes o chicos; que tan fríos o calientes; que tan viejos o jóvenes son estos objetos. En esta búsqueda cuentan con la ayuda de ojos gigantes, ojos con forma de telescopios.

Los telescopios son herramientas que ayudan a los astrónomos y astrónomas a ver más grandes las estrellas, planetas y galaxias. La mayoría de los telescopios que están en el norte de Chile son tan grandes como una casa, y pronto, habrá uno del porte de un estadio de futbol.

Pg.16
Los grandes telescopios necesitan estar en lugares muy especiales para tomar buenas imágenes del universo. De hecho, solo hay tres lugares en el mundo donde los telescopios pueden trabajar perfectamente.

Pg.17
Uno de ellos es el Desierto de Atacama.

Pg .18
Para ver las estrellas, los telescopios necesitan buen clima y cielos oscuros. En el Desierto de Atacama no hay luces de ciudad, ni nubes, ni cielos movedizos. Los cielos movedizos hacen que las estrellas titilen, los cielos tranquilos hacen que las estrellas se vean quietas. ¿Y si tú quisieras tomarle una foto al cielo de noche, qué le dirías? "¡Quédate quieto!"

Pg19

Ojala yo pudiese pedirle lo mismo a Yakana, pero ella no va a parar hasta que encuentre agua fresca. Está tan apurada ¡que ni siquiera se ha dado cuenta que su cría bajo a la tierra! Menos mal. Porque si Yakana la ve, la pondrá a dormir de vuelta en el cielo, y nosotros nos quedaremos solos en el desierto…

Pg.21

¡Vamos! No podemos dejar que Yakana se nos escape. Aún necesitamos bajar de Los Andes y cruzar la pampa hasta alcanzar la Cordillera de la Costa, para llegar hasta el cerro más alto de la región, Paranal. Allí está el observatorio más moderno del mundo. Sus telescopios son tan especiales que fueron los primeros en fotografiar un planeta fuera de nuestro Sistema Solar. Usar los telescopios de Paranal, o cualquier otro gran telescopio, es un premio para los astrónomos y astrónomas.

Pg.24

Los astrónomos recolectan mucho material en una noche de observación. Tanto, que las imágenes que recolecten esta noche les servirán para trabajar por todo un año o más.

Los astrónomos y astrónomas trabajan duro.
Después pueden tomarse un recreo. Paranal tiene muchos lugares para relajarse.
De vuelta en la oficina, aún hay mucho que hacer. Y una vez que encuentran algo nuevo…
¡Publican la historia para contarle al resto del mundo las buenas noticias!

Pg.26

¡Que suerte que podemos ver todos los grandes telescopios en una sola noche! Sigámosle la pista a Yakana, tú estas haciendo un buen trabajo. Ahora llego el momento de viajar hacia el sur. Estamos dejando atrás la región de

Atacama, pero el desierto aún no nos abandona. Este aire nos seca la nariz, nos deja los labios salados, mientras escalamos otra vez, hasta que alcancemos el Observatorio Las Campanas.

Pg.28
¿Estas cansado? Es bien difícil respirar en estas alturas; hay poco oxigeno en la cima de las montañas. Estamos viajando por lugares tan difíciles de alcanzar, que incluso los astrónomos prefieren mirar el cielo sin moverse de la ciudad.

Pg. 29
¡Si! Los astrónomos pueden decir exactamente donde quieren mirar y otra persona desde el observatorio apunta el telescopio por ellos. Los astrónomos recibirán las imágenes en sus computadores, en el país donde viven. Igual, todos los observatorios reciben astrónomos visitantes, como Las Campanas, famoso por recibir muchas visitas. Pero para nosotros, es tiempo de partir. Sigamos caminando, antes de que salga el sol.

Pg. 30
Usemos el poco tiempo que nos queda para mirar al cielo otra vez. Desde acá, podemos observar cosas que la mitad del mundo no puede ver; maravillas como el centro de la Vía Láctea y dos galaxias lejanas llamadas Nubes de Magallanes. Bellezas como estas solo se pueden ver desde la parte sur del mundo.

Pg. 32
Por eso, cuando el Observatorio Gemini quiso explorar el cielo desde los dos lados del mundo, construyo telescopios gemelos. Pusieron un telescopio en Hawaii y su hermano en este desierto, en Cerro Pachon. Juntos, estos telescopios idénticos pueden observar todo el cielo.
(En ilustración: **¡MAMA!**)

Pg.33
¿Crees que Yakano lo escuchó? No podemos darnos el lujo de perderla ahora. Ya casi hemos terminado nuestro recorrido.

Pg. 34
¡Eso estuvo cerca! Pero lo logramos, llegamos a los dos últimos observatorios: La Silla y Tololo.

Pg. 35
Tololo fue el primer observatorio que se construyó en este desierto. Poco tiempo después La Silla se instaló acá también. Con el tiempo, todos los observatorios que visitamos esta noche llegaron a este desierto atraídos por sus fantásticos cielos. Muy pronto, observatorios mucho más poderosos florecerán en esta tierra. Telescopios inmensos, que serán capaces de buscar planetas parecidos a nuestra Tierra, girando entorno a otras estrellas, como nuestro sol.

¡Oh-oh! ¡El sol! Ya va a salir…

En ilustración:
- ¡Mama!
- ¡Lanudito! ¿Qué haces tú aquí abajo?

Pg. 38
El desierto ya esta a punto de cambiar. Llegara la mañana, reinara el sol, y el calor quemara la tierra, otra vez. Ha sido un gran viaje, gracias por caminar con nosotros. Eso si, no creas que lo has visto todo, porque mientras mas miras, más hay para ver. Aquí, los ojos del desierto siempre estarán bien

abiertos. Aun hay muchos secretos escondidos en el universo para que alguien los encuentre. ¿Serás tú quien los descubra?

Pg. 41
Fin

Pg.42

Una nota sobre los observatorios

Los chilenos siempre han tenido curiosidad por la astronomía. El primero que quiso construir un observatorio en Chile fue Bernardo O'Higgins, el mismo hombre que peleo por la independencia de Chile a principios de 1800s. Poco antes de morir, el escribió una carta dirigida al presidente donde le sugería que seria una buena idea construir un observatorio astronómico.

El sueño de O'Higgins no se cumplió entonces, pero al poco tiempo, un equipo de astrónomos de Estados Unidos viajo a Chile para observar Venus y Marte desde la parte sur del mundo. Ellos construyeron un observatorio en el Cerro Santa Lucia (Santiago), y una vez que se fueron, ese lugar se convirtió en el primer Observatorio Astronómico Nacional de Chile (en 1852).

Con el tiempo, el Observatorio Nacional se mudo a tres locaciones diferentes. Como cada vez empezó a vivir mas gente en Santiago, se hacia mas difícil encontrar un lugar lejos de las luces de la ciudad y del polvo que levantaban los peatones y los caballos que caminaban sobre las calles sin pavimentar. Hoy, el Observatorio Nacional esta en Cerro Calan (Santiago), y es uno de los lugares importantes donde jóvenes chilenos estudian para convertirse en astrónomos y astrónomas.

Todos los grandes telescopios que visitamos en este libro están ubicados en Chile, pero le pertenecen a otros países. Sin embargo, el Observatorio

Nacional fue muy importante para conseguir que estos telescopios gigantes se construyeran en Chile por dos razones. Primero, porque los astrónomos del Observatorio Nacional eran muy buenos y esto le dio una buena reputación a Chile. Y segundo, porque el Director del Observatorio Nacional, Federico Rutllant, viajo por el mundo para contarle a todos que Chile tenia cielos espectaculares para la astronomía. Entonces, la calidad de los cielos sumado a la gran calidad de los astrónomos chilenos convirtieron a Chile en uno de los mejores lugares del mundo para explorar el universo.

Una nota sobre Yakana

El cielo esta lleno de animales. No animales de verdad, pero de animales que la gente ve al dibujar líneas imaginarias entre las estrellas. Estas figuras se llaman 'constelaciones'.

Yakana es una constelación. La diferencia entre ella y la mayoría de las constelaciones es que ella no esta hecha de estrellas, sino de manchones oscuros que se pueden ver en la Vía Láctea (igual, uno de sus ojos es una estrella). Yakana era una constelación popular entre los pueblos nativos del norte de Chile. Ellos creían que Yakana bajaba a la tierra para beber agua. Ellos también creían que si alguien la veía caminar, Yakana le traería felicidad y mucha suerte.

Una nota para ti

Cuando yo supe que el desierto chileno tenia tantos telescopios gigantes, quise contártelo enseguida. Yo soy una escritora, y no sabia mucho sobre astronomía, así es que tuve que aprender. Visite los observatorios y converse con astrónomos, astrónomas, y con las distintas personas que trabajan allí. Espero que este libro te inspire para aprender más sobre astronomía también. Te recomiendo visitar algunos sitios web de los observatorios, ya sea por si quieres conocer más sobre los telescopios, o simplemente para disfrutar de increíbles fotos y videos. O quizás, ¡por si quieres visitar uno de los

observatorios en persona! Muchos de ellos organizan visitas para el publico. También encontraras más información sobre estas visitas en los siguientes links.

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