Justification and Persuasion about Cloning: Arguments in Hwang's Paper and Journalistic Reported Versions

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Abstract We examine the argumentative structure of Hwang et al.'s (2004) paper about human somatic cell nuclear transfer (SCNT, or 'therapeutic cloning'), contrasted with four Journalistic Reported Versions (JRV) of it, and with students' summaries of one JRV. As the evaluation of evidence is one of the critical features of argumentation (Jiménez-Aleixandre 2008), the analysis focuses on the use of evidence, drawing from instruments to analyze written argumentation (Kelly et al. 2008) and from studies about the structure of empirical research reports (Swales 2001). The objectives are: 1) To examine the use of evidence and the argumentative structure of Hwang et al.'s *Science*, 303: 1669–1674 (2004) original paper in terms of the criteria: a) pertinence of the evidence presented to the claims; b) sufficiency of the evidence for the purpose of supporting the claims; and c) coordination of the evidence across epistemic levels. 2) To explore how the structure of Hwang's paper translates into the JRV and into university students' perceptions about the evidence supporting the claims. The argumentative structure of Hwang's paper is such that its apparently ostensible main claim about NT constitutes a justification for a second claim about its therapeutic applications, for which no evidence is offered. However, this second claim receives prominent treatment in the JRV and in the students' summaries. Implications for promoting critical reading in the classroom are discussed.

Keywords Argumentative structure · Cloning · Evidence · Journalistic reported versions · Therapeutic cloning

Argumentation, Evidence and Persuasion in Scientific Texts: Rationale and Objectives

Argumentation and discourse analysis studies are drawing attention to the discursive practices related to learning science, among them the evaluation of knowledge claims, a central feature in argumentative environments (Jiménez-Aleixandre 2008). A genuine

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vehicle for communicating new knowledge claims among the scientific community is the scientific paper. Subsequently, this knowledge is reaching the public through popularized summaries or Journalistic Reported Versions (Nwogu 1991), thereafter JRV. Scientific literacy should equip the future citizens with the capacity to understand the JRV and even to be able to cope with some primary sources. A central feature of scientific papers should be the commitment to evidence. This paper examines the use of evidence and the argumentative structure of Hwang et al.'s (2004) original paper about human somatic cell nuclear transfer (SCNT, also called therapeutic cloning), contrasted with four Journalistic Reported Versions of it, and with university students' summaries of one JRV. The study makes part of a project about scientific competencies, exploring the capacities to draw appropriate conclusions from evidence and to criticize claims made by others on the basis of evidence, paying attention to the processes of reading and writing scientific texts. This University of Santiago (USC) based project is part of RODA (ReasOning, Debate and Argumentation), an ongoing research program exploring argumentation, classroom discourse and epistemic practices through classroom studies. The rationale draws from two frames, on the one hand argumentation studies, on the other hand studies about writing and reading scientific texts. We see both strands related to the role of discursive practices in scientific work.

Argumentation and Evidence Evaluation

The emerging line of research about argumentation in science classrooms points to the central position of the evaluation of knowledge claims in argumentation (Jiménez-Aleixandre 2008). The evaluation of knowledge is an epistemic practice, defined by Kelly (2005) as proposing, justifying and evaluating knowledge claims; we would add that evaluating might include criticizing. Sandoval and Reiser (2004) define epistemic practices as the cognitive and discursive practices involved in making and evaluating knowledge. These last authors point out that students' activities are different from the real activities of professional scientists, and propose engaging students in the reasoning and *discursive* practices of scientists. In the study from which this paper makes part we examine students engaged in a discursive practice: assessing research about human cloning and the evidence supporting different types of claims related to this controversial line of research.

One of the critical features of argumentation is the evaluation of evidence. The use and evaluation of evidence by students is receiving growing attention in educational policy and in the science education literature. Using evidence, in terms of both supporting claims with evidence and criticizing claims on the basis of evidence, makes part of the competencies evaluated in the OECD Programme for International Student Assessment (PISA), being one of the components of its definition of scientific literacy (OECD 2003). The evaluation of evidence in a scientific report would involve assessing how strongly its claims are supported by the evidence provided. We propose that this assessment could be based on three criteria, from which numbers 2 and 3 are drawn from Kelly et al. (2008) frame for the analysis of written argumentation:

1) Pertinence: Does the evidence presented relate to the claims?
2) Sufficiency: Is the evidence sufficient to support the claim?
3) Coordination: Are pieces of evidence coordinated across different epistemic levels?

We thought it is necessary to include criterion 1, since although it may seem obvious that the evidence has to be connected to the report's claim, this is not always the case, as any experienced journal referee knows. Criterion 2 does not need further elaboration. Criterion

3, following Kelly et al. (2008), relates to the articulation of evidence from particular graphs, inscriptions or data, to theoretical models necessary for the construction of the argument. As Kelly et al. point out a good argument should combine evidence at different epistemic levels in order to achieve a solid justification of the claims.

A substantial part of argumentation studies on the last years has focused on verbal argumentation in classroom settings. However, written research reports have an underlying argumentative structure and its analysis may contribute to our understanding of both scientific argumentation and the strategies needed in order to foster scientific literacy in the classroom. We turn now to the literature about reading and writing scientific texts.

Writing Scientific Texts: Evidence and Persuasion

One of the reasons for the current under emphasis on reading and writing in science education is, according to Goldman and Bisanz (2002) that reading and writing seem implicit in the work of scientists and are taken for granted. They suggest a second reason, a distorted image of the epistemology of science, highlighting students' engagement in experimentation. Goldman and Bisanz plead for a stronger emphasis on reading and writing in science education, suggesting that it is important for scientists (and, we would say, teachers) to recognize the need for instructional scaffolding in order to foster the acquisition of reading and writing skills and the development of a critical stance toward scientific communication. We would add that, as argumentation and discourse analysis studies advocate, there is a need for attention to the discursive practices related to learning science, among them the evaluation of knowledge claims.

In the last decade, a consensus is growing around the perspective acknowledging both the central role of reading and writing in science and in science learning, and the literacy component of scientific literacy (Norris and Phillips 2003; Yore et al. 2003) that involves, for instance, critical reading of different sources, or participation in debates and argumentation (Yore et al. 2003). We conceive scientific literacy as equipping students, among others, with the competencies: a) to understand newspaper reports about science, to unpack the scientific concepts underlying them; and b) to evaluate claims on the basis of evidence, evaluation that, as the argumentation studies suggest, is also a central component of learning science.

Our rationale draws from studies about writing and reading scientific texts, in a perspective considering them as part of the social processes involved in the production of knowledge (Myers 1990). Scientific papers possess an argumentative structure, articulating evidence to support claims at various levels, for instance, about the interpretation of results, or the significance of the study. But they also present persuasive features, as one of their goals is to convince a particular audience. As Myers points out, scientific texts use narrative devices to convey certain meanings and make difficult to imagine alternative interpretations. Papers have a role in the construction of knowledge and also in determining the place of the authors in the scientific community. It is worth noting that both justification and persuasion are meanings of argumentation (Jiménez-Aleixandre and Erduran 2008).

In this paper we examine the use of evidence and the argumentative structure of Hwang et al.'s (2004) original paper about human somatic cell nuclear transfer (SCNT, also called therapeutic cloning), contrasted with the structure of four JRV of this same paper. We examine also the students' evaluation of the evidence presented in one of the JRV. The work presented here makes part of a wider study on students' argumentation about cloning, that was in its preliminary steps when Hwang et al. (2004) reported the first nuclear transfer (NT) in humans on February 12, 2004. The report received wide coverage in the media,

partly analyzed in another place (Federico-Agraso and Jiménez-Aleixandre 2008), being followed by a second paper in 2005. In December 2005, while our study was progressing, the paper was exposed as a fabrication and subsequently *Science* retracted it in January 2006. This raises the question of whether there is a different reception of the work among the students working about it before and after this exposure. The objectives of the study are:

1) To examine the use of evidence and the argumentative structure of Hwang et al.'s (2004) original paper in terms of the criteria: a) pertinence of the evidence presented to the claims; b) sufficiency of the evidence for the purpose of supporting the claims; and c) coordination of the evidence across epistemic levels.
2) To examine the use of evidence and the argumentative structure of four JRV, in terms of the same criteria, and particularly which evidence and claims from the original paper were translated into them.
3) To examine the evaluation by university students of the evidence presented in one of the JRV.

Methods, Samples and Tools for Analysis

Participants, Samples, Task

For objective 1 a scientific report: Hwang et al. (2004) original paper, published in *Science*. It has to be noted that, although the paper date is March 12, it was published on line on February 13.

For objective 2 we selected four journalistic reported versions (JRV) from two Spanish newspapers that have the greatest impact, which were also published on February 13. From them two are written by Spanish leading scientists in the field, and two by journalists specializing in Science. Table 1 summarizes the sample of papers for objectives 1 and 2, which will be subsequently mentioned by its first author.

For objective 3, the participants are four groups of University students (N=149). From them, 83 (40 with a biology background, 43 without it) completed the task before

Table 1 Scientific paper and journalistic reported versions analyzed (Spanish titles are translated)

Authors	Journal /Newspaper	Title	Authors' profile
Hwang et al.	*Science*, 303: 1669–1674; March 2004	Evidence of a pluripotent human embryonic stem cell line derived from a cloned blastocyst	Scientist, Seoul National University (Korea)
Soria	*El País*, 13 February 2004 (page 30)	Therapeutic cloning is possible	Scientist, Elche University (Spain)
Raya & Izpisúa	*El País*, 13 February 2004 (page 30)	One step toward regenerative medicine	Scientists (Spanish born) San Diego, Salk Institute
Jáuregui & Boto	*El Mundo*, 13 February 2004 (front page, continued in pp 34–35)	First proven cloning of human embryos opens a new age for science	Journalists, Science & Health specialists
Sampedro	*El País,* 13 February 2004 (page 29)	The key to success	Journalist, Science specialist

December 2005, when the paper was exposed as a hoax, and 66 (50 with, 16 without a biology background) competed it in 2006. The task made part of the activities in their science education courses.

Task: the JRV from Soria, was distributed to students and they were asked to a) summarize it, and b) to write two or more reasons for and against this type of research.

Methods of Analysis

The argumentative analysis of the scientific report and JRV draws, on the one hand, from studies on the structure of different genres of scientific communication. Such as the structure of empirical research reports (Bazerman 1988; Swales 2001), which correspond to the genre of communication among scientists; as well as the differences in structure and organization between those reports and JRV (Goldman and Bisanz 2002; Nwogu 1991), related to the rhetorical moves in the process of transformation of a research report into a JRV, with the purpose of popularizing the information. On the other hand it draws from instruments, schemes and rubrics for analyzing arguments (Kelly et al. 2008; Toulmin 1958; Walton 1996). First the arguments from different sections of the papers are identified, then their integration in the overall structure of the text is examined, in terms of how its claims are supported by the evidence presented (pertinence), which is the strength of the evidence (sufficiency), and which type of argumentative structure it presents (coordination).

The structure of empirical research reports corresponds to five standard sections (Swales 2001): introduction, experiment methods, experiment results, discussion and implications. As Hwang's introduction has particular features explored in our analysis, it is worth noting Swales' proposal about the structure of the introduction in four moves: establishing the field, summarizing previous research, preparing for present research and indicating present research (cited in Nwogu 1991, p. 113). Nwogu (1991) coined the term Journalistic Reported Version (JRV), and identified nine rhetorical moves in the process of transformation of a research report into a JRV, moves that involve a pattern restructuring, or reordering of the canonical sequence of research reports. Some of these nine moves have been reworded or expanded by Goldman and Bisanz (2002), resulting in: 1) presenting background information and hooking the reader; 2) highlighting major research outcome; 3) reviewing related research; 4) presenting research purpose; 5) stating important results; 6) describing data collection procedure; 7) describing experimental procedure; 8) explaining research outcome and 9) indicating research implications.

Kelly and colleagues have proposed and tested different instruments for the analysis of the structure of arguments using Toulmin's (1958) argument components, particularly claim, data and justifications (Toulmin's warrants). Two of these instruments are relevant for the purpose of this paper, first the taxonomy of justifications (warrants) in Kelly et al. (1998). In particular the categories for justification strategy: direct or subsequent, meaning that a simple justification is used in support of the claim (direct), or that the justification constitutes another argument (subsequent), being the claim of this second argument the justification for the first. We think that the notion of subsequent justification is useful in the analysis of complex arguments as those in scientific reports. Second, specific for the analysis of written argumentation (Kelly et al. 2008), we draw the criteria about sufficiency and coordination, which, besides pertinence, are used to evaluate the evidence in the reports. Kelly et al., also propose an argument model that may account for the complexity of the argumentative structure of a written report. As they point out, the writers in the report "are not attempting to make a single move from data to a claim. Rather, through a series of claims about varied data sources they attempt to build a complex argumentation structure."

(Kelly et al. 2008, p. 142). The model is graphically presented as several lines of reasoning, progressing from the basic epistemic level of data inscriptions, to low inference claims, which support another level of claims, combined into theoretical claims, which support the final thesis. We think that this is a fruitful model that can be adapted to the particular structure of the paper analyzed in each case. For instance, the structure in four levels of the argument about Nuclear Transfer (NT) in Hwang's paper, discussed below, is represented in Fig. 1.

For objective 3, the evaluation of evidence by students, a list of categories was produced in interaction with the data, as discussed in the findings.

Argumentative Structure and Evidence in Hwang's Paper

First we will discuss the results for objective 1, the examination of the use of evidence and argumentative structure of Hwang's paper in terms of the criteria of pertinence and sufficiency of evidence, and of its coordination across epistemic levels. It has to be noted that the analysis takes all evidence and claims in the paper as if they were true, although we now know that data were forged.

The steps in the analysis: first we read each paragraph and summarized its main content in one label. Then each sentence in the paragraphs was examined in terms of argument components and its contribution to the argument or arguments in the paper. Hwang et al. "Evidence of a pluripotent human embryonic stem cell line derived from a cloned blastocyst" has 1874 words (excluding abstract and references), distributed in eight paragraphs (P1 to P8), ranging from 387 to 119 words, and from 16 to five sentences, which, in accordance with *Science* style, are not preceded by section titles. These paragraphs correspond to the canonical structure of research reports (Bazerman 1988; Swales 2001): P1 introduction, P2 to P4 methods, P5 and P6 results, P7 discussion and P8 implications.

Each sentence was examined and assigned to a category of argument components, then the categories were refined and the coding for each sentence revised. As a result of several iterative cycles of analysis, four argument components were identified in the paper: data inscription, evidence, justification and claim. By *data inscription* we mean the photographs, microscopic images, karyotypes, tables, graphics, DNA fingerprints etc., all of which are labeled as tables or figures in the paper. By *evidence*, in the context of this paper, we mean sentences about experimental results supporting the claims. For instance in sentence 5,4 (paragraph 5, sentence 4): "When cultured in defined medium conditioned for neural cell differentiation (*20*), SCNT-hES-1 cells differentiated into nestin-positive cells, an indication of primitive neuroectoderm differentiation (Fig. 1F)", all the sentence but the last bracket (that refers to Fig. 1F, a data inscription), is considered evidence contributing to the claim about the pluripotency of the cell line. The *justification* establishes the connection between data or evidence and claim. By *claim*, we mean the thesis that the authors are seeking to demonstrate. As discussed below we interpret that there are two main claims in the paper, about Nuclear Transfer (NT) and about therapy (Th). Table 2 summarizes the analysis of these eight paragraphs in terms of the main content and of the contribution to the argumentative structure of the paper.

The ostensible main claim of the paper is to be found in the title: "Evidence of a pluripotent human embryonic stem cell line derived from a cloned blastocyst", as well as in paragraph 1, sentence 7; we have coded it as NT second level claim (see Fig. 1). We can unpack it as being composed of two lines of argument: one, in P7, marshalling evidence
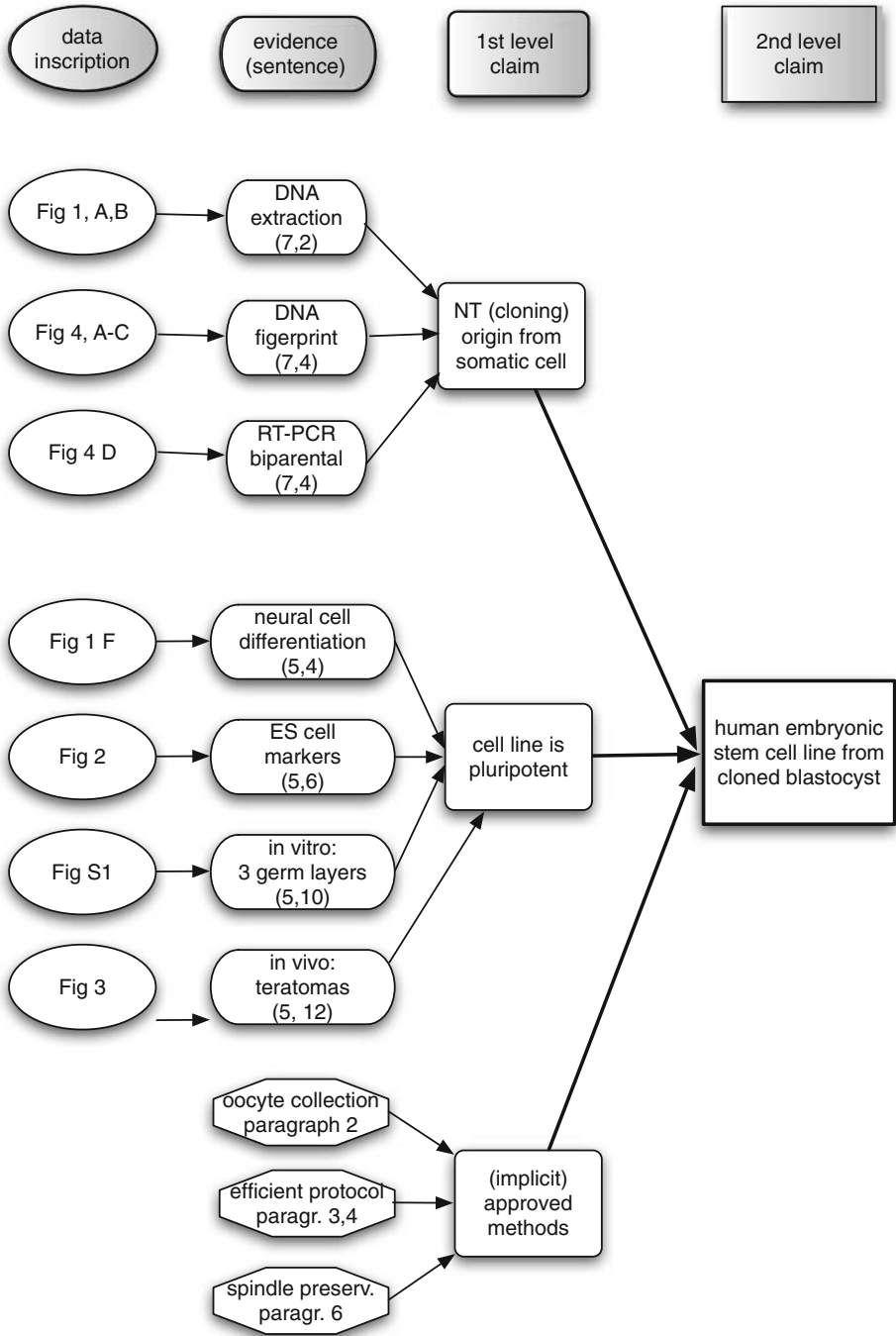
Fig. 1 Hwang's paper argumentative structure for NT claim. Numbers (e.g. 7,2) correspond to paragraphs and sentences in the paper

Table 2 Structure of Hwang et al.: w=words; s=sentences; h-ES = human embryonic stem; SCNT = Somatic cell nuclear transfer; NT = Nuclear transfer argument; Th = Therapy argument

Paragraph: # of words & sentences; section in report	Main content (sentence number)	Argument element
P1: 207 w, 7 s	Major research outcome:	
Introduction	– h-ES cells (7)	NT 2nd level claim
	– therapeutic applications (1 & 5)	Th 3rd level claim
P2: 249 w, 11 s		NT evidence
Methods (samples, general)	Oocyte collection & enucleation	(approved methods)
P3: 119 w, 5 s	Development of an efficient protocol:	NT evidence
Methods (technical details)	Reprogramming time	(approved methods)
P4: 346 w, 13 s	Development of an efficient protocol:	NT evidence
Methods (technical details)	Oocyte activation & culture	(approved methods)
P5: 387 w, 16 s	Cell line is pluripotent (8):	NT 1st level claim
Results (details of main outcome)	– 3 germ layers (4, 10, 12)	NT evidence (plur.)
	– undifferentiated morphology (5)	NT evidence (plur.)
	– XX karyotype (5)	NT evidence (clone)
	– DNA fingerprinting (14)	NT evidence (clone)
	– RT-PCR biparental expression (16)	NT evidence (clone)
P6: 180 w, 7 s		NT evidence
Results (details of methods)	Spindle complex preservation	(approved methods)
P7: 177 w, 9 s	3 lines of evidence for NT origin (1):	NT 1st level claim
Discussion	– DNA extraction verified (2)	NT evidence (clone)
	– heterozygous chromosomes (3)	NT evidence (clone)
	– RT-PCR biparental expression (4)	NT evidence (clone)
P8: 209 w, 9 s Implications	Therapeutic applications; further research	

about the origin of the cell line in *nuclear transfer* from a somatic cell, in other words, in cloning (and ruling out alternative possibilities, as parthenogenetic origin); another, in P5, marshalling evidence about the *pluripotent* features of the cell line, in other words, that it constitutes an embryonic stem cell line. These two lines of argument lead to claims that we have coded as NT first level claims. From these two claims, the first one has greater relevance; being the first time that successful cloning was reported for humans. The authors begin paragraph 7 with this sentence "In this report, we provide three lines of evidence supporting the nuclear transfer origins of the SCNT-hES-1 cell line". These three lines are then summarized, although they have been already discussed in P5. Although the pluripotency, that is the capacity of differentiating into every cell type, is important, it is not a scientific breakthrough; the first sentence of the paper refers to Thomson's article about it published in 1998.

In our opinion, to these two explicit claims, each one supported in several lines of evidence, a third line of argument has to be added: the use of approved methods in the field, resulting in an implicit claim about the legitimacy of the study. As can be observed in table 2, there are four paragraphs, numbers 2, 3, 4 and 6, providing evidence about the methods. In P2, reporting oocyte collection, the first five sentences relate to the selection of donors and the consent form, which makes part of the supporting online text. P3, P4 and P6 report optimization of protocols by the authors. Reporting methods makes part of the canonical structure of research papers, but perhaps in this case it has a role in the legitimization of the study, being Hwang a veterinary, with no previous record about human NT research. The argumentative structure of the paper in relation with the NT claim, by means of an adaptation of Kelly et al. (2008) model, is represented in Fig. 1.

The result of the examination of the lines of evidence articulated in the NT claim, in connection with objective 1, is that the evidence is pertinent, sufficient and articulated at different epistemic levels, from data inscriptions to theoretical first-level claims.

There is a second claim in the paper, that we coded as Th, that in its most straightforward wording would be that the purpose of this research is therapy. These words were used by Hwang in interviews with journalists, when he said that their work pursued only curing disease (quoted in Jauregui's JRV). In the paper this idea is conveyed indirectly through sentences 1, 2 and 5 in P1:

> "The isolation of pluripotent human embryonic stem (ES) cells (*1*) and breakthroughs in somatic cell nuclear transfer (SCNT) in mammals (*2*) have raised the possibility of performing human SCNT *to generate* potentially unlimited sources of undifferentiated cells for use in research, with potential applications in *tissue repair* and *transplantation* medicine. This concept, known as '*therapeutic* cloning', refers to the transfer of the nucleus of a somatic cell into an enucleated donor oocyte (*3*). [...] When applied in a *therapeutic setting*, these cells would carry the nuclear genome of the *patient*; therefore, it is proposed that after directed cell differentiation, the cells could be *transplanted* without immune rejection to treat *degenerative disorders* such as *diabetes, osteoarthritis*, and *Parkinson's disease* (among others)." (Hwang et al. 2004, pp 1669–1670, emphasis added).

The last part of sentence 1 states that human NT is performed "*to generate* potentially unlimited sources of undifferentiated cells for use in research, with potential applications in *tissue repair* and *transplantation* medicine." (our emphasis). Then sentence 2 gives this technique its popular name, *therapeutic* cloning. Sentence 5 discusses potential applications of NT to therapy, using terms as patients and citing several examples of disease. These three sentences add to 119 words, more than half of the 207 words of P1. In our opinion, from these references to therapy, only the mention of therapeutic cloning (between quotation marks) in sentence 2 seems warranted in the introduction. In particular, the detailed discussion of therapeutic applications in sentence 5 seems inappropriate, as it lacks connections with the reported results (even if these were true). If it had a place in the paper, it would be in the last section, implications, where it is mentioned again.

The question, in connection with objective 1, is: Which evidence is articulated in support of this Th claim? Is it pertinent and sufficient? But the analysis of the paper yields not a single piece of evidence connected to this claim: first, it would be difficult to provide evidence supporting that the purpose of the authors' research is therapy, for intentions are not testable. The only evidence we have about it is external to the paper: because it was later exposed as forgery it seems that the purpose of the *Science* paper was rather oriented towards objectives as securing the author's position in the scientific community and facilitating funds raising (what is legitimate, provided it is accompanied by true research results). Second, it would be difficult also to provide evidence supporting that NT research would shortly be translated into therapy. Most authors concur that such therapies may not be available in the next decade. Moreover, some of the first attempts of using stem cells (not from NT origin) in the treatment of neurodegenerative disorders had problematic outcomes (Molinatti 2007), as these active pluripotent cells may originate tumors. So, if we examine how the Th claim is supported, our interpretation is that it is achieved through one piece of data, part of sentence 5 in P1 "these cells would carry the nuclear genome of the patient" and two justifications, one in the same sentence "therefore, [...] the cells could be transplanted without immune rejection", and the other, in the type of subsequent justification, the 2nd level claim in the NT argument. In other words, the therapy claim is

not supported by empirical evidence reported in the paper, but on the one hand in the whole argument about a stem cell line of NT origin (conveying the idea that human NT is feasible), and on the other on (hypothetical) data about the identity between donor and cell line connected to the justification about transplantation. Figure 2 represents the structure of this second Th argument in Toulmin's layout.

The analysis of the reception of Hwang's paper in the media, in our case of a sample of JRV about it, can illuminate the prominence of both claims, trough the examination of whether they are highlighted or omitted.

How the Journalistic Reported Versions Translate the Argumentative Structure

The examination of the use of evidence and argumentative structure of the four JRV of the Hwang's paper, began by identifying in each one of them a) the claim or claims; b) the data inscriptions mentioned or reproduced, including original figures produced by the newspapers; c) the evidence mentioned or summarized; d) the justifications. On the course of the analysis, we had to include also two other elements that were not needed for the analysis of Hwang's paper: e) data and f) qualifiers. Following Toulmin (1958), *data* are the grounds on which the claim is based. Sometimes it is used as synonymous for evidence, but here we have given evidence a restricted meaning, as the experimental results supporting the claim. *Qualifiers* point to limits in the claims. Table 3 summarizes the argument elements in the JRV.

There are other elements in the JRV not corresponding to argument elements, although relevant for analyzing other features in their structure, for instance sentences or paragraphs about: methods (e.g. preservation of mitotic spindle, high number of eggs); review of previous research, implications for the future (e.g. clinical applications), ethical issues (e.g. moral constraints to the use of human eggs or embryos, risk of reproductive cloning), regulations and research policy in different countries.
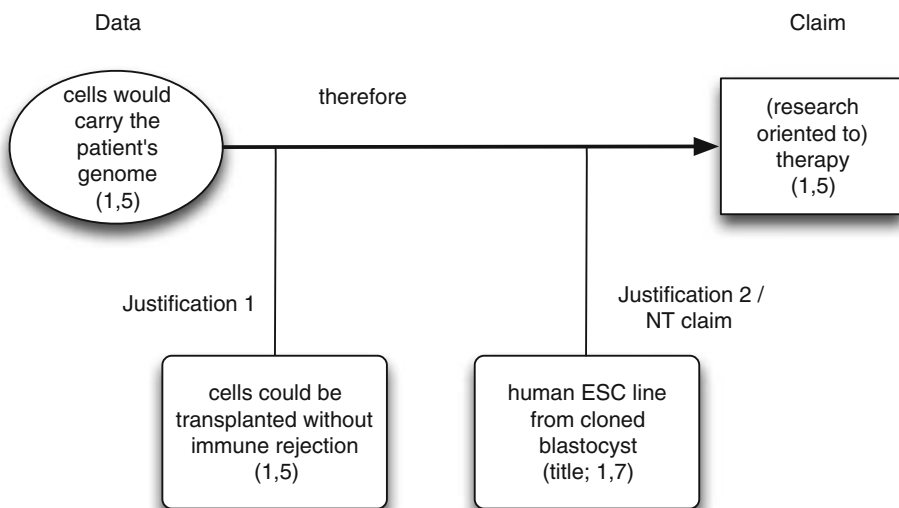

Fig. 2 Hwang's paper argumentative structure for therapy claim. Numbers (e.g. 1,7) correspond to paragraphs and sentences in the paper

Table 3 Summary of argument elements in the JRVs. Between brackets the paragraph and sentence number. NT, nuclear transfer; Th, therapy

Argument elements	Soria	Raya & Izpisua	Jauregui & Boto	Sampedro
NT & Th Claims	– Th: Therapeutic cloning is possible (title)	– Th: One step toward regenerative medicine (title)	– Th: 1st therapeutic cloning of human embryos with therapeutic purpose (title)	– NT: Key to success: an enormous number of human eggs (headline)
	– NT: NT work in humans (1,2–4; 4,1)	– NT: NT can be a reality in humans (6,3)	– NT: First time that human embryonic stem cells are produced (11,1)	
NT Data inscription	Micrograph of cloned embryos	Micrograph of cloned embryos	– 3 diagrams – 4 micrographs from Science	– 2 diagrams
Th Data	– (stem cell) with same genetic endowment as the donor (1,5)	– cell lines from blastocysts genetically identical to the patients (2,2)	– (tissues) would originate from material genetically identical to his own (3,1)	– transplanted tissues would be genetically identical to the patient (9,2)
NT Evidence	– publication in *Science* means acceptance (1,1) – egg enucleation (3,5)		– (transplant to mice) proved that cells could yield different tissues types (9,3) – extraction of nucleus (9,2)	
Th Justification	– therefore perfectly compatible immunologically (1,5) – cell line with great capacity for differentiation (1,4) – reprogramming human adult cells is possible (5,2)	– theoretically the risk of rejection of transplanted tissues would be eliminated (2,1)	– all tissue types that the patient would never reject (3,1)	– (transplanted tissues) would not induce the lesser rejection (9,2) – stem cell potential for differentiation in neurones etc (8,1)
NT & Th Qualifier		– there is a long way from human NT to efficient & safe therapy applications (8,3)	– much work to be done before it can reach the patient (12,1)	– clinical applications will take years (7,1)
			– eggs & nucleus from the same woman (12,3)	– weakness: eggs & nucleus from the same woman (14,1)

About the argument elements, as can be observed in Table 3, three of the JRV combine claims about nuclear transfer and therapy, while the focus of Sampedro, whose JRV was published on the same *El País* issue as Soria and Raya & Izpisua, was mainly on NT and on the reasons why Hwang had succeed where others failed. Nevertheless, Sampedro's JRV also included two paragraphs, (8 and 9, see Table 3), about therapy. Given that three JRV combine two types of claims, it could be expected that the other argument elements would be related to both. However, as seen in Table 3, data inscriptions and the four pieces of evidence belong to the NT argument, while all the data and justifications correspond to the Th argument. Only in the modal qualifiers elements from both arguments are found: references to the long way to therapeutic applications in three JRV (absent also from the primary source, which only mentioned the need for protocols improvement), and mentions, in two JRV, to the weak point in the paper, the fact that both egg and nucleus originated from the same woman. It is worth noting that in all the three JRV that contain the therapy claim, it is on the headlines or in the title, while the NT claim is a sentence in the body of the text.

In terms of the use of evidence, it can be said that, with the exception of the mentions of the *in vivo* mice test by Jauregui, and of the egg enucleation by two authors (Soria and Jauregui & Boto), the NT evidence is omitted in the JRV. It has to be noted that the first piece of evidence belongs to the argument line about pluripotency (see Fig. 1), and not to the more relevant line about the cloned origin of the h-ESC line. The enucleation belongs to the cloning line, although in both cases it is placed in the paragraphs about methods. For Soria JRV, we have coded as evidence the sentence "Publication in *Science* means the acceptation by the scientific community that the so-called therapeutic cloning is possible". Since it is the first sentence in the paper, we interpret that for its author counts as evidence, in other words, its discursive role is one of evidence. It is evidence related to NT, not to Th. Nevertheless, is it a sort of meta-evidence connected to the legitimization of the research, and cannot be considered experimental evidence, as are the results in Hwang's paper.

However, when it comes to the data and justification for the therapy claim, the four JRV reproduce, with slightly different wordings, the ones used by Hwang: the cell lines and tissues would be genetically identical to donors, so there would be no rejection of transplants.

As a result, on three JRV (all, except Sampedro) there is a stronger emphasis on therapeutic applications than in the original paper, both quantitatively, in terms of paragraphs content, and qualitatively, in terms of argumentative structure. The argumentative structure of these three JRV is almost the same to the Th argument in Hwang's paper represented in Fig. 2. As an instance, the argumentative structure of Soria, the JRV used with students, is represented in Fig. 3. It can be noted that the pluripotency ("capacity for differentiation", Fig. 3), which in the primary source was one of the lines of evidence contributing to the NT argument, here is used, not to support the NT claim, but as justification for the Th claim: "it is probable that some day we would know how to reprogram adult cells and transform them into the cells that our patients need".

How Students Interpret the Claims and Evidence in one JRV

First we examined the students' summaries with the purpose of locating the ideas that they had identified in Soria JRV, and then their reasons for and against that type of research. The written answers of the students were read and a preliminary list of categories was produced. Each author coded the students' summaries, which yielded an agreement of 86%. Then the
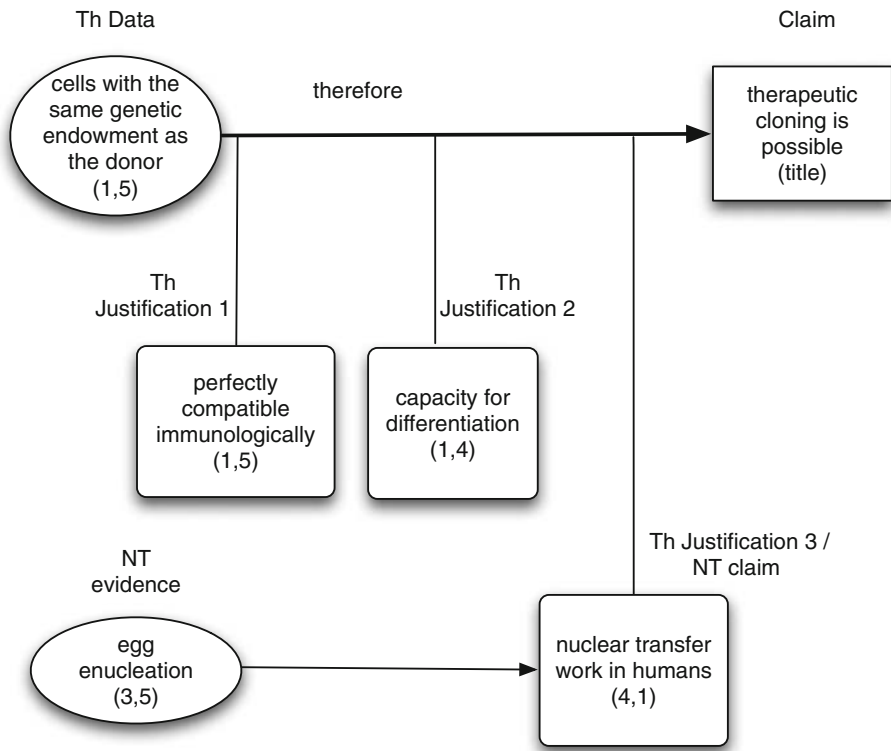
Fig. 3 Soria JRV argumentative structure. Numbers (e.g. 1,5) corresponding to paragraphs and sentences in the paper

categories were refined, the differences in coding discussed until consensus was reached, and the data were subjected to a revised analysis. The results of the claims and evidence identified are summarized in Table 4 (without the data from the 16 students without a biology background in 2006, because they completed only the second part of the task).

As seen in the Table 4, more than 84% of students from all groups identified both NT and therapy claims. As discussed in the previous section, Soria JRV only included one piece of experimental evidence from Hwang's paper, the egg enucleation, so it would be

Table 4 Claims and evidence identified by students in B. Soria's article: NB = without a biology background; Biology = with a biology background. $N = 133$

Claims and evidence identified	NB N=43	NB %	Biology N=90	Biology %
Claims				
Nuclear transfer (NT) claim	36	84%	77	85%
Therapy (Th) claim	38	88%	84	93%
Evidence / Justifications				
NT Enucleation of egg (Evidence)	31	72%	65	72%
NT Development to blastocyst	17	39%	42	47%
NT Cell line capable of differentiation	8	19%	42	47%
Th Cell line genetically identical to donor	21	49%	39	43%

impossible for the students who read only the Soria's paper to mention another evidence. 72% of students in both groups identified the egg enucleation evidence, and part of them also mentioned the development to the stage of blastocyst, probably because it was mentioned twice in the first paragraph of the JRV. Although we do not consider the development to blastocyst a piece of evidence it may be possible that for the students it counts as evidence, which needs to be explored through interviews in further research. About the identification of justifications, the identity between cell line and donor is mentioned by over 40% of the students, while the capacity for differentiation is the only issue where there are appreciable differences between students with and without biology background. The argumentative structure of students' summaries matches closely the structure of the JRV that they were asked to summarize.

The examination of the reasons that the students offered for and against this type of research may illuminate whether they view the issue predominantly as nuclear transfer or as therapy. Table 5 summarizes these reasons given by 149 students.

The therapeutic applications are first among the reasons 'for', with a frequency higher than 80% in both cases, despite of lack of evidence about it. To this category other reasons had to be added, such as transplantation (that could be collapsed with therapy, were it not that many students mention both separately) and assisted reproduction. These three first categories seems to point that the students perceived therapy as the most prominent claim in the JRV. The second reason in frequency is advance in knowledge. There are smaller differences in percentages between the reasons offered in support of NT research by students with and without a biology background, than between the reasons against it, although the biology students provided more, and more sophisticated, reasons 'for' human

Table 5 Reasons for and against research about NT in humans: NB = without a biology background; Biology = with a biology background. $N = 149$

Reasons	NB N=59	NB %	Biology 90	Biology %
Reasons in support of NT				
Therapy, curing diseases	52	88%	75	83%
Transplantation	7	12%	35	39%
Assisted reproduction	5	8%	6	6.5%
Advance in knowledge	20	34%	34	38%
Replacing the use of human embryos	3	5%	7	8%
Recovery of endangered species	1	2%	4	4.5%
None	1	2%	6	6.5%
Other	4	7%	–	–
Reasons against NT research				
Ethical (unspecified)	13	22%	36	40%
Use human embryos / eggs	11	19%	28	31%
Potential misuse (unspecified)	8	13.5%	16	18%
Non therapeutic use (eugenics)	10	17%	13	14.5%
Risk of reproductive cloning	9	15%	4	4.5%
Commercial purposes	5	8.5%	12	13%
Consequences unpredictable	11	19%	5	5.5%
Low technical efficiency	2	3%	21	23%
Other	17	29%	9	10%
None	–	–	20	22%

cloning. The reasons 'against' present more dispersion. Ethical concerns are the most frequent reasons, but in a high proportion remain unspecified, and when specified, limited to a narrow range of ethical issues. For instance, risks for egg donors (coded in 'other') are only mentioned by three students without a biology backgrouond (NB) and one student with a biology background (B). A 23% of biology students (and a 3% of NB) appeal to low efficiency, which may be interpreted either as confusing technical with ethical issues, or alternatively as a perception of the issue (which was referred in the task only as "this type of research") as one of nuclear transfer, not of therapy.

It is worth mentioning that while all the NB students offered some potential reasons against this research, there was a 22% of the Biology students who offered none, some of them explicitly stating that they could not think of any reason against it. None of the students who participated during 2006 ($N=66$), 50 of them with biology background, 16 from journalism, seemed aware of Hwang's work being a hoax.

Discussion and Educational Implications

The argumentative structure of Hwang's primary paper, examined with criteria of pertinence and sufficiency of evidence, and coordination across epistemic levels, is such that, although apparently its main claim should be nuclear transfer (NT) or cloning—in other words, that human embryonic stem cells have been produced—this line of multiple evidence constitutes a subsequent or subordinated argument used as justification for a second claim: the possibility of transplantation medicine and other therapies. But no experimental evidence is offered for this second claim. This conclusion is supported for instance by the position of the paragraphs, first and last, and sentences discussing therapy. The introductory paragraph, besides setting the research in context and stating the purpose of the study, devotes the first and fifth sentences to discuss therapeutic implications. For us these subtle deviations from the canonical structure correspond to rhetorical moves having persuasion as a goal, rather than justification. As analyzed elsewhere (Jiménez-Aleixandre and Federico-Agraso 2007) the exposure of the Hwang paper as a hoax, and the attention drawn to it, uncovered a number of features lending support to this hypothesis. In our opinion it would be as if an educational paper discussing learning difficulties would present as conclusion a hypothetical solution of these difficulties without offering evidence for it.

This argumentative structure is translated into the Journalistic Reported Versions (JRV), which give prominence to the therapy claim, although not offering evidence for it. Even one line of evidence, pluripotency, that in the primary source is used to support the nature of the cell line (that they are stem cells), is used in the JRV as a justification of the therapeutic applications of the research (that they could generate the type of tissues required by patients). The relative prominence of the therapy and NT claims is evidenced for instance in the position in the texts, headlines or title (therapy) versus body text (NT).

The examination of the summaries of one of the JRV by university students shows that most of them (84% or more) identified both claims, NT and therapy, citing the evidence and justifications mentioned in the JRV, which were mostly oriented to therapy. This perception of the research is also evidenced in the reasons offered in support of it, where therapy figures prominently.

The prominence of therapy has been discussed by Magnus and Cho (2005), in a paper, focusing on the donors' question, published in *Science* before Hwang work was exposed as a forgery. They point out what they call the *therapeutic misconception*. This misconception, for them, is a lack of recognition of the large gap between research and therapy, namely the

distance of years or maybe decades between research and its potential clinical benefits. For them "the language used to describe the research can reinforce the therapeutic misconception misleading donors and subjects into believing that research is therapy" (Magnus and Cho 2005, p. 1748), with the consequence of exploitation of vulnerable patients and their family. For them the accurate term is 'hESC research', not 'therapeutic cloning', because there is currently no such thing as 'therapeutic cloning'. They extend their critique to terms as 'cell therapy' or 'patients' that they see as contributing to confusion.

This critique does not imply an opposition to NT research, but just an acknowledgement of the complexity of the issue, and the need for students and the public at large, to be given the opportunity of evaluating its advantages and disadvantages before forming an opinion or having, eventually, to take a decision about it. For this purpose, popularizing texts and JRV with as less bias as possible would be desirable.

For the purpose of developing scientific literacy in the classroom, we agree with Myers (1990) proposal of five strategies to develop critical reading in order to support the apprenticeship of reading and writing science. These are: look for the rhetorical, reconstruct the social context, look for related texts, look for the source of authority, and look for links between scientific and everyday language. As the particular focus of our research is the use of evidence, we are currently preparing an adaptation (translated into Galician) of Hwang's paper, based on Baram-Tsabari and Yarden's (2005) notion of adapted primary literature (APL), which would preserve its structure, in order to explore how the students identify the coordination between evidences and claims in it.

References

Baram-Tsabari, A., & Yarden, A. (2005). Text genre as a factor in the formation of scientific literacy. *Journal of Research in Science Teaching*, *42*, 403–428.

Bazerman, C. (1988). *Shaping written knowledge: The genre and activity of the experimental article in science*. Madison: The University of Wisconsin Press.

Federico-Agraso, M., & Jiménez-Aleixandre, M. P. (2008). Therapeutic cloning? Discourse genres, ethical issues and students' perceptions. In M. Hammann, M. Reiss, C. Boulter, & S. D. Tunnicliffe (Eds.), *Biology in Context. Learning and teaching for the twenty-first century* (pp. 315–326). London, UK: University of London.

Goldman, S. R., & Bisanz, G. L. (2002). Toward a functional analysis of scientific genres: Implications for understanding and learning processes. In J. Otero, J. A. León, & A. C. Graesser (Eds.), *The Psychology of science text comprehension* (pp. 19–50). Mahwah: Lawrence Erlbaum.

Hwang, W. S., Ryu, Y. J., Park, J. H., Park, E. S., Lee, E. G., Koo, J. M., et al. (2004). Evidence of a pluripotent human embryonic stem cell line derived from a cloned blastocyst. *Science*, *303*, 1669–1674.

Jiménez-Aleixandre, M. P. (2008). Designing argumentation learning environments. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 91–115). Dordrecht: Springer.

Jiménez-Aleixandre, M. P., & Erduran, S. (2008). Argumentation in science education: An overview. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 3–27). Dordrecht: Springer.

Jiménez-Aleixandre, M. P., & Federico-Agraso, M. (2007). Students' reception of Hwang's work through the media: Ethics and rhetoric. Paper presented at the ESERA conference, Malmoe, August.

Kelly, G. J. (2005). Inquiry, Activity, and Epistemic Practice. Proceedings of the Inquiry Conference on Developing a Consensus Research Agenda, Rutgers University, February 2005. Retrieved on September 2006 from the conference website: http://www.ruf.rice.edu/+AH4-rgrandy/NSFConSched.html

Kelly, G. J., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: combining performance assessment with argumentation analysis. *International Journal of Science Education, 20*, 849–871.

Kelly, G. J., Regev, J., & Prothero, W. (2008). Analysis of lines of reasoning in written argumentation. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 137–157). Dordrecht: Springer.

Magnus, D., & Cho, M. K. (2005). Issues in oocyte donation for stem cell research. *Science, 308*, 1747–1748.

Molinatti, G. (2007). Médiation des sciences du cerveau. Approche didactique et communicationnelle de rencontres entre neuroscientifiques et lycéens. Doctoral dissertation. Museum National d'Histoire Naturelle. Paris.

Myers, G. (1990). *Writing biology. Texts in the social construction of scientific knowledge*. Madison: The University of Wisconsin Press.

Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education, 87*, 224–240.

Nwogu, K. N. (1991). Structure of scientific popularizations: A genre-analysis approach to the schema of popularized medical texts. *English for Specific Purposes, 10*(2), 111–123.

Organisation for Economic Cooperation and Development [OECD] (2003). *PISA assessment framework — mathematics, reading, science and problem solving knowledge and skills*. Paris: Author.

Sandoval, W. A., & Reiser, B. J. (2004). Explanation-driven inquiry: integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education, 88*, 345–372.

Swales, J. M. (2001). *Genre analysis: English in academic and research settings*. Cambridge: Cambridge University Press first edition, 1990.

Toulmin, S. (1958). *The uses of argument*. Cambridge: Cambridge University Press.

Walton, D. N. (1996). *Argumentation schemes for presumptive reasoning*. Mawah: Lawrence Erlbaum.

Yore, L. D., Bisanz, G. L., & Hand, B. M. (2003). Examining the literacy component of science literacy: 25 years of language arts and science research. *International Journal of Science Education, 25*(6), 689–725.