A Narrative Analysis of Stem Cell Research Scientists' Reflections on Ethical Issues and the Value of Science

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Abstract: The purpose of this study is to explore the ways in which scientists reflect on the scientific practices, based on the premise that reflection is one of key elements for shaping scientific identities. This paper specifically considers scientists' reflections as the processes in which their senses of ethical issues and the value of science are articulated. To do so, the study developed a narrative inquiry for exploring the value of scientists' stories. Fourteen professional scientists' stories were collected in the context of the stem cell research, in ways that foreground their reflections on current scientific practices and the surrounding socio-cultural conditions. As for ethical issues, scientists' stories were analysed in terms of four claims regarding the themes of bioethics, integrity, scientific issues and communication. Furthermore, scientists' reflections on the value of science were analysed in relation to the elements of nature of science. Based on the results, discussion focused on the value of science stories as an instrument with which to guide students into the enculturation in the practices of scientific culture.

Key words: science stories, scientists, scientific practice, nature of science, bioethics.

I. Introduction

The nature of science (NOS) was introduced in the science curriculum in many countries (AAAS, 1993; NRC, 1996) as the means to achieving scientific literacy that can be complementary to more traditional, content-based learning (Kolstø, 2001; Osborne *et al*., 2003). Recently, there has been an increased interest in understanding scientists' views of NOS by considering them as the curricular resources for the scientific practices and cultures of professional science (Glasson & Bentley 2000; Wong *et al*., 2009). Studies began to consider the 'authentic' contexts that shape everyday lives of practising scientists as informing more elaborative ways of understanding how science really works in the realm of professional scientific research (Rudolph, 2003; Schwartz *et al*., 2004). Other studies directly attempted to utilise scientists' descriptions of their work as windows into more realistic and elaborate views of the nature of contemporary science and scientific inquiry (Yore *et al*., 2004; Schwartz & Lederman, 2008; Wong & Hodson, 2010). In spite of the efforts for explicating scientists' epistemic beliefs, however, methodological issues arising in empirically investigating scientists' discourse are rarely articulated. In our view, such a discussion is a missing point in the research area focusing on authentic scientific practices, since different methodological approaches can yield different sets of data and tools with which to examine ways in which scientists make sense of their everyday scientific activities.

This study aims to explore the ways in which scientists reflect on the meanings of scientific research, based on the premise that reflection is one of key elements for shaping scientific identities (Schwartz *et al*., 2004; Samarapungavan *et al*., 2006). This paper specifically considers scientists' reflections as the processes in which their senses of ethical issues and the value of science are articulated. In terms of methodology, the idea of scientists' stories is developed in the sense that they enable us to explore their reflections on current scientific practices and the surrounding socio-cultural conditions; namely, scientists' ethical sense-making (see the following section).

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Scientists' stories are considered as meaningful texts in which the values of science and scientific knowledge are elucidated by the scientists, and the scientists actively construct scientific identities (Michael, 1996). Following Kelly *et al.* (1998), we adopt a socio-cultural perspective that focuses on the discourse processes and practices through which situated definitions of science are constructed: namely, we are interested in studying science-in-the-making (Latour, 1987), especially the ways in which "what counts as science is accomplished" (Kelly *et al.*, 1998, p.26). Therefore, rather than aiming to elicit scientists' 'views' of the NOS, we attempt to describe how scientists interpret meanings of science particular to their local field of scientific research and communities. The study's concern with naturalistic approaches to the epistemology of science is also congruent with the idea of 'enacted epistemologies' shared by a particular scientific community (Samarapungavan *et al.*, 2006).

The study makes use of interview data with fourteen practising scientists in the area of stem cell research. The interview study was designed on the premise that scientists' experience-based narratives can add a more nuanced voice from the 'field' to our understanding of the value of stem cell research and ethical issues that needed to be considered. The debate over the use of human embryos for deriving stem cells is a prime example which shows how some ways of scientific innovation can be constrained by cultural values and social decision-making processes. Also, stem cell researchers are nowadays asked to become more aware of the social and ethical implications of their research activities, especially given that public perceptions of the benefits, uncertainties and risks concerning new scientific and medical technologies are very often incongruent to the 'scientific' understanding. Therefore, the stem cell research is an apt context in which the value of scientific research is actively pursued in a closer relationship with the debate on its ethical implications. Two aspects of scientists' stories in this study are analysed in order to investigate the characteristics of scientist's reflection that are relevant to the context of stem cell research:

1) What are the ethical issues?
2) What is the value of science?

Based on the analysis of the two themes of scientist's reflection, we discuss the meanings of reflection in the scientists' stories, and develop a heuristic model for investigating reflection in scientists' stories that can be used in science classrooms. We conclude with suggestions for science education.

Ⅱ. Rationales for narrative inquiry into scientist's reflection

In science education literature, concerns with narrative have focused on the use of science narratives as a complementary form of discourse to more familiar 'detached' text genres such as explanation or argumentation, in ways that promote students' interest in and understanding about scientific text through their active engagement with the stories (Solomon, 2002; Norris *et al.*, 2005; Avraamidou & Osborne, 2009). Whilst many studies have paid attention to the effects of specific narrative genres such as historical narratives or fictional narratives on science learning, others concerned the way in which the role and authority of the scientist is suggested in the narrative construction of scientific text. For example, Milne (1998) identified the fact that the heroic science story - a hero of science single-handedly contributing to the development of science - dominated schools' science textbooks. She discusses the power of science stories, arguing that science stories reveal implicitly something about the NOS, therefore serve to legitimate particular philosophical frameworks. In her view, while the heroic science story implies that it is not possible to suppress true scientific knowledge, its emphasis on the privileged status of scientific knowledge may lead students to imagine that they cannot achieve the highest level of understanding achieved by the great heroic scientists (also in Martin & Brouwer, 1991). Contrary to the heroic image of scientists in school science, tensions between the values of science and scientists, and those of society do exist in reality. Indeed, science stories can be told differently in ways that reveal "many subtle undercurrents that link science, society and technology, and reflect the culture in which we live and frame our values" (ibid, p.718).

It is in this vein that this study tries to elicit scientists' stories as the means for both constructing and exhibiting scientists' ways of making meaning out of ethics, as the case which illustrates the interactions between societal moralities, cultural values and norms, and the roles and identities of scientists espoused by the scientific community itself. In terms of narratives, the study pays attention to scientists' ethical sense-making as involving their explications about who did what, how and why; and these are represented through a form of narrative structure. Specifically, the study's interest is concerned with the argumentative characteristics of narratives and their relationship to identity. Narratives become argumentative when the protagonist engages in justifying, explaining and making sense of one's conduct, career, values and circumstances, therefore making 'identity claims' (Barker & Galasiske, 2001; Mills, 2001). This suggests, for narrative inquiry, that the main focus in analysing scientists' argumentative narratives should be concerned with their (own and other) ascriptions about the roles and responsibility of dealing with ethical problems arising from new scientific innovations and ideas.

With these ideas in mind, the study conceptualises scientists' stories as a form of narrative. Stories typically consist of protagonists (in this case, the scientist), events and reflections on events. Narrative analysis has to do with "how protagonists interpret things" (Bruner, 1990, p.51). Bruner (1991) established the view that telling a story is basically concerned with arguments of action: that is, it reveals agents (who did what); their intentions, goals and situations surrounding the action (how and why it happened) and consciousness (what those involved in the action know or feel). Based on these three dimensions, scientists' stories will be elicited in three aspects and in association with the study's concerns (see Fig. 1): they include, i) actors related to the question of who is the agent, and so forth, involving various parties who make claims about the scientists' responsibility or integrity including the scientists themselves the theme directed to identify more than 'hero' scientist identity; ii) events and acts related to the cultural pressures or norms that demand scientists to behave more ethically and responsively to socio-cultural issues the theme pursued through current science and technology policies and movements, and finally, iii) reflection on events related to the scientists' consciousness on those social and cultural values the study's novel interest. This conceptual framework has common features with other narrative frameworks in that it foregrounds the narrator's role and points of view in interpreting what happens in this case, the scientist (Avraamidou & Osborne 2009). What is novel in this study's framework is to allow an integrative approach to the scientists' identity construction or claims in responding to the question: "What is required of scientists when dealing with ethical issues?" In this study, these ideas were used as conceptual tools with which interview questions were generated for an empirical investigation of scientists' stories.

Understanding viewpoints possessed by ordinary scientists ('ordinary' in the sense that, like others, scientists are ordinary professionals faced with ethical dilemmas) can be insightful in de-mystifying the dominant fairy tale which leads to a model of an heroic scientist (Harre, Brockmeier & Muhlhauser, 1999). That is, scientists are able to reflect on the norms and

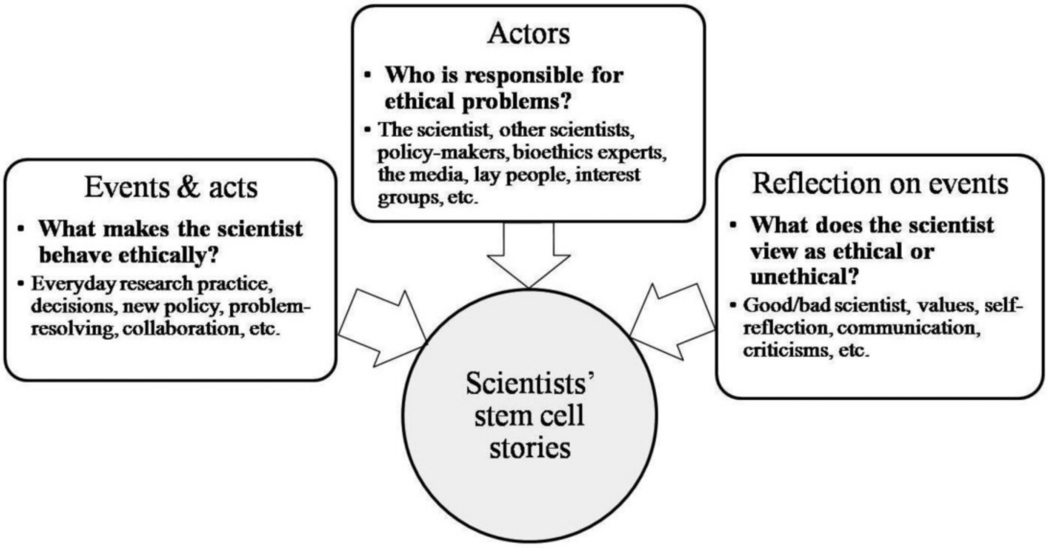

Fig. 1 *Ethical sense-making in the scientist's stories*

values of science, and their stories expose the chasm between the normative goals pursued in terms of scientific values and the practical dilemmas faced in everyday practices (also in Waterson *et al.*, 2001). In this study, we follow Waterson *et al.* (ibid., p.2) in defining 'reflective discourse' as part of an informal, contingent repertoire, which captures, in the scientists' talk, the fact that "the scientists are reflecting and talking about science, rather than representing science". For the study, the idea of 'reflective discourse' has been framed by the explicit interest in the scientists' sense-making in order to explore ethical consciousness as something more than that which can simply be read off 'scientific views' on ethical issues (e.g. Longstaff *et al.*, 2009).

From this viewpoint, 'the value of science' is a rhetorical accomplishment purported by the scientific community, rather than a priori. Whilst demarcation of science from non-science is also regarded as a goal or rationale for science education, it has long been a subject of debate within the philosophies and sociologies of science. For Comte, Popper and Merton, science should be defined by its unique epistemological characteristics, whereas more recently, sociologists have stressed boundary-making as scientists' rhetorical strategies for claiming their epistemic authority over non-scientist groups or non-scientific intellectual domains (Gieryn, 1983; Gilbert & Mulkay, 1984). Discourse analysts have investigated the latter by employing the ideas of an empiricist repertoire and a contingent repertoire: an empiricist repertoire refers to a pattern of discourse in which a scientist's interpretative activities are seen as irrelevant, therefore the account is presented as if derived from fact. By contrast, a contingent repertoire is employed by scientists in depicting the fact that others' (non-scientists or peer scientists) beliefs and actions are influenced by factors outside of the empirical realm, such as personal bias and political motivation (Gilbert & Mulkay, 1984). Nevertheless, since their original use by Gilbert and Mulkay, others have used the same ideas in more nuanced modes for examining variation in scientists' use of the two repertoires indifferent situations and with different purposes (Mckinlay & Potter, 1987; Waterson *et al.*, 2001; Davies, 2008). The idea of contingent repertoire is apt for the study's empirical investigation of scientists' stories in the sense that scientists' views of ethical issues and the value of science are debatable and contingent in nature, rather than epistemologically fixed.

Ⅲ. Method

1. Interviews

In total, fourteen scientists were interviewed for the current study. All fourteen scientists were professional research scientists who were actively engaged in the stem cell research. Except for two junior researchers at post-doctoral level, all possessed more than ten years' professional experience. Only one scientist was female and another four were medical doctors who were actively engaged in research work. All fourteen stem cell researchers, including medical doctors, were based in universities, five of them specialising in embryonic stem cell research whilst the other nine were in adult stem cell research. No scientists interviewed worked in the area which actually involved the derivation of human embryonic stem cells through the somatic cell nuclear transfer technique, or so-called 'therapeutic cloning' (see Appendix for scientific terms). As a result, the scientists' views in this study mainly focused on the 'research' rather than the more applied area, such as clinical practice or therapies. Therefore, the qualitative data excluded the view of private sectors, whilst still partly suggested from the standpoint of the interview participants. Therefore, although the participants' profiles do not necessarily represent 'the scientist's views' on specific issues, the study sought to reveal some of the characteristics of scientist's reflective discourse.

Since interviews explicitly aimed to facilitate the scientists' reflective thought processes, trust between the researcher and interview participants was essential in the process of gaining consent for the interviews. In this, the researcher's various cross-disciplinary backgrounds in biology, social science and bioethics enabled her i) to discern the various standpoints based on their expertise, which may frame the issues very differently, and ii) to communicate effectively with the interview participants, through showing understandings about, and sympathy for, their views and orientations. By so doing, the interview method was framed by the cultural approach suggested by Waterson et al. (2001, p.6), for "interrogating scientists' own sense of meaning in the work that they are engaged upon, and to try to understand how their thoughts and actions made sense, or were meaningful, in their particular autobiographical and professional situations." Semi-structured interview questions aimed to elicit the scientists' experientially-grounded 'contingent repertoire', related to the area of research, views on bioethical issues, problems in scientific practice, the status of Korean science, and the role of the scientist (Table 1), but were applied flexibly depending on the interviewees' experiences and the focus of their concerns. Interviews were held for one or two hours, and all were audio-taped and transcribed (6000-10,000 words per transcript). All names remained anonymous as promised prior to the interviews.

2. Narrative analysis

Scientists' ethical sense-making structure was identified through the coding of related themes: bioethics, integrity, scientific issues and communication (see Table 2). The themes were first derived inductively through iterative coding and then operationalised by deriving empirical indicators from interview participants' statements (Wengraf, 2001). For example, the theme of bioethics was based around indicators such as 'support', 'opposition', 'embryos', etc. The next step was to explore the relationship between these story elements with a view to 'interlocking narratives' (Levinson, 2009). Levinson (2009) developed a story of aluminum, by using the cycle of linked events relating to

Table 1
Interview questions

Main questions	Keywords
1. What is the area of your research?	Expertise, interest, motivation, etc.
2. What is your view on bioethical issues?	Pro/anti-embryo, social debate, regulations, etc.
3. What do you see as the problems in scientific practice in promoting ethical behaviour?	Laboratory life, Korean culture, the scientist's social status, etc.
4. What is your view on the current status of Korean science in the stem cell field?	Scientific policy, infrastructure, competition, comparison with Western countries, etc.
5. What do you think of the scientist's role in dealing with ethical issues?	Individuals' conscience, collaboration, scientific community, the media, etc.

the manufacture of aluminum. Each event is, in turn, linked to a narrative with aluminum as the agent. The difference in this study is that the agent is scientist, not material, and the focus of linking is on the scientists' ideas (codes), not the event. However, the idea of interlocking narratives was still instrumental in establishing a link between the idea of the scientists' ethical sense-making (as identified in Fig. 1) and the empirical findings (as categorised in Table 2). To establish validity, member-checking was used: the main researcher and her research assistant continued to read material until the interpretation of meaning was agreed by both. This was also concerned with the issue of credibility in qualitative research, as their goal was to tell stories that readers could come to believe as they were narrated (Lincoln & Guba, 1985). Overall, the scientists' ethical sense-making involved scientists' personal and collective ways of interpreting the needs and challenges necessary for addressing ethical issues of stem cell research.

In analysing each of the four themes (or codes), actors, acts and the reflection element were identified in following ways. 'Bioethics' typically concerns the debates on the use of human embryos for research, involving conflict and/or negotiation between the various interest groups in society, such as religious groups, feminists, NGOs, scientists and so on. Whilst all fourteen scientists saw that human embryos can be used for research purposes, it is important to note that the majority saw bioethics in terms of the need to facilitate 'good' scientific research rather than principles or cultural values. Importantly, interlocking four themes or codes has meant that 'bioethics' is only part of larger story elements in the scientists' ethical sense-making. For them, the idea of 'integrity' makes sense in this context, thus 'interlocked', as the essential component of the 'good' scientific research. Integrity has also become the powerful policy agenda after the Hwang Woo Suk scandal. However, for the scientists, ethical conscience should be cultivated, as people become the participants of communities of scientific practice. Then, their ethical sense-making naturally points to the systematic and cultural problems that they saw as restraining ethical awareness from being fostered. In this, many scientists, particularly junior researchers, pointed out that the laboratory culture lacks active communication and mutual respect between the members. Therefore, even though it was admitted that there have been many efforts made to establish the ethical guidelines to the letter, scientists viewed the quality of scientific culture and the national research infrastructure as the prerequisite conditions. This explains why the recent, strict bioethical regulation policy is often regarded as an effort to match the

Table 2
Four major codes or themes

Bioethics	Integrity	Scientific issues	Communication
1–a Support	2–a Research ethics	3–a Aims of research /Basic idea	4–a Trust
1–b Opposition	2–b Commercialisation	3–b Diverse methods	4–b Ignorance
1–c Human eggs	2–c Risk	3–c Trends in research	4–c Expectation
1–d Religion	2–d Research infra–structure	3–d Evidence	4–d Media
1–e Social consensus	2–e the Korean culture	3–e Breakthrough	4–e The role of the scientist/scientific community
1–f Others	2–f Lab	3–f Hurdles (scientific, financial, etc.)	
1–g Incurable disease/ patients		3–g Collaboration	
1–h Bioethics law/ policy/ regulations		3–h Basic research	
1–i Institutional Review Board		3–i Clinical trials	
1–j Internationalism/ The Western view		3–j Therapy	
1–k Scientific view		3–k Korean science	
1–l Hwang scandal		3–l Policy	
		3–m International competition	
		3–n Peer–review	
		3–o History	

'Western' scientific standard. Meanwhile, 'communication' was related to scientists' social responsibility for the social controversy arising from the uncertainties and risks that new science and medical technologies entail.

Through the iterative interpretation process, our understanding of the scientists' stories of ethical issues was framed by the narrative characteristics in terms of the scientists' claims of scientific identities and their association with the cultures of science. Four claims were identified on the four themes derived from the data: namely that bioethics is a matter of policy or social consensus; that scientists are capable of knowing about ethical issues; that commercialism should be addressed; and finally, that the public should be well–informed (Fig. 2). Obviously, these themes cannot be generalised, however, they can be understood as some crucial elements of scientists' reflection on what is 'ethical' thing to do as a scientist living the contemporary age. While the claims are very general statements that are commonly found in the fourteen scientists' interview scripts, the variance between them was explored in terms of individual scientists' views on the role of scientists as intellectual or responsible experts in society, and the larger social, political and economic contexts (both within and outside of scientific practice) wherein such interpretations are born and embedded. In Result 1, we describe in detail the content, and present the controversy over the SCNT as the case in point which shows distinctively all four aspects in the

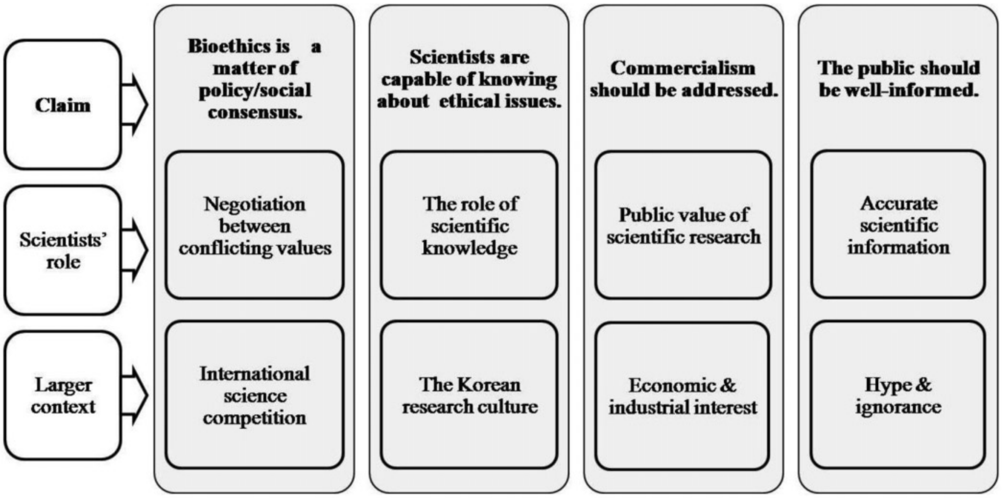

Fig. 2 *The narrative characteristics of ethical issues in the scientists' stories*

scientists' sense-making of ethical issues.

For investigating the research question 2, the same data was analysed in terms of the salient NOS aspects in the scientists' stories. In the stem cell research context, the scientists' understanding about what is considered valuable in scientific inquiry was mainly concerned four specific themes: first, the idea of basic research the aim concerns production of new knowledge, relative to clinical, applied research; second, different research topics and source materials such as human embryos; third, the role of scientific community in responding to socially controversial ethical issues; and finally, scientific views on the current ethical regulation. The NOS aspects directly concerning the stem cell

Table 3
Salient NOS aspects in the stem cell research context

Nature of Science (Drivers *et al.*, 1996)	Stem cell research context	Illustrative themes
The purposes of scientific work	Basic /clinical research	• A Biologist seeking understanding about cell functions/ discovered micro RNAs specific to hESCs.
		• Collaboration sought between bench scientists and doctors.
The nature and status of scientific knowledge	Selection of research topics among human embryos, somatic cells & iPS	• Preference on using the existing hESC lines rather than creating the cell lines because of the regulatory issue.
		• Realistic assessment on the SCNT technique as original technology [also, Result 1]
		• Somatic cell nuclear transfer & iPS for reprogramming
Science as a social enterprise	The scientific community	• Ethical behaviour should be promoted more in Korea in order to enhance the quality of research
	Ethical regulation	• International standards and national interest as the driving force

research context were elicited, based on Drivers *et al.* (1996) (see examples in Table 3). Since space is too limited to describe each example, the overall picture of the NOS aspects will be described with a case of one scientist's interpretation of scientific value in Result 2. Also, the idea of 'original technology' will be further analysed, as a particular discourse about the value of science.

Ⅳ. Results: scientists' reflection on ethical issues and the value of science

1. What are the ethical issues?

Analysis of four claims on ethical issues

The view that bioethics is a matter of policy or social consensus suggests the scientists' conscious awareness on the interaction between science and society, and the need for scientists to become more responsive to social debates and public concerns. As S and Q claim in the following, scientists nowadays need to be aware that social debate and policy decision-making processes are necessary parts of new science and technology development in order to deal with public concerns and conflicts:

> Although I myself am not involved in hESCs, I believe the issue in the end is about what is good for humans. I don't see ethics and science as being in opposition. (S)

> I try to speak my views in public. Without the public's acceptance, it's not science, only self-satisfaction. The reality is, we need social consensus in order to get policy support. (Q)

The scientists also noted that bioethical regulation policy varies in many countries, for example, to destroy human embryos for research purposes is not supported in Germany, whereas Britain adopts the most permissive approach by allowing the creation of human admixed embryos for research. Many scientists pointed out the change in US policy from no state support for hESC research during the Bush administration, as a case in point that shows the logic of national interest in the economic potential of stem cell therapies overpowering the moral debate on the use of human embryos. Thus, they considered bioethics to be a matter of policy-decision, which is inevitably affected by international science competition:

> In my view, nations shall follow the British policy, as the USA did. It's all about national interest, not ethics, at the end of day. (S)

For the scientists, a more worrying issue was scientists' misconduct, as the Hwang Woo-suk scandal showed. However, their sense of agency was seriously lacking: that is, even though scientists claim, in many cases very strongly, that they are capable of knowing about ethical issues, they were facing practical challenges in practice. The scientific culture should be something that fosters individual scientists' professional growth, which is the precondition for an ethical scientist. The Korean research culture, in their view, was lacking the ability to make a voice when encountering systematic issues such as outcome-driven, application-focused scientific policy:

> We need to get humanities education before we get scientific education. There is too much stress on technology. The Korean Scientific community cannot address such problems since there's no collaboration or leadership. Most seriously, we need a system, which ensures the improvement of the working conditions of the junior researchers. (P)

> Korea is very weak in basic research, and it's focused so much on the applied area that it can produce results in a very short time. We don't have much original technology, so

> we rely on overseas protocol. (b)

Even so, scientists were able to show their awareness of the integrity issues, especially from the viewpoint that the value of science research should be strictly assessed through scientific criteria. Scientists' ideas about 'scientific value' will be analysed in further detail in Result 2, but here, we should note that the scientists' way of defining 'ethical' heavily depends on the current state of scientific understanding certified through the strict peer-review process by the field's experts. Therefore, scientists who relate something without the scientific knowledge base should be considered 'unethical' scientists:

> Only a few stem cells have a clinical effect; even the researcher himself doesn't know whether they are effectively or not. In this situation, he must not argue that it will have clinical effects. (a)

For a similar reason, commercialism should be shunned as much as possible from scientific activities. Scientists' criticism focused on the stem cell therapies that are provided in clinics in the absence of any scientific assessment on their safety and efficacy. C criticises those who sell stem cell products, whilst P also does so by stressing further the importance of a scientific knowledge base as the criterion that clinicians must use when explaining to their patients the effects of the treatment that they are being given:

> It seems to me that life scientists must obey rules in society. Human existence is more important than economic values. Profits or national economy shouldn't be an absolute value. (C).

> A scientific research should be judged by knowing what the outcome is and what is not. However, some scientists try to use their patients to make profits, and it's a serious problem. (P)

Clearly, scientists' conception of the 'public' value of scientific research was concerned with the contribution of scientific knowledge to advancing understanding about, and cures of, diseases. The problem of stem cell therapies was also noted due to its cost, not only its scientifically-unproven effect:

> People think stem cells derived through the SCNT [even if successful in the future] can cure anybody, but in fact it's not true [because it's patient-specific]. It can become a kind of luxury item, but of course, more research should be done in comparison with iPS, in order to determine its value. (Q)

The final dimension of the ethical argument concerns public understanding of science and the role of scientifically-informed communication. Overall, the scientists were very concerned about the misconceptions and hypes that still exist in the public perception of the medical potential of stem cell research. b was particularly frustrated that his patients will not listen to him because what he says is scientifically true but is not what they wish to hear:

> Even though I try to explain from a neutral perspective, my patients don't believe me, because I don't give them hope, only the facts. (b)

Thus, the scientists regarded the gulf between the scientists' expert knowledge and public expectation as very large:

> Stem cell research has been regarded as something like the World Cup, not as a science. I always feel cautious. Some only see negative aspects, whereas others are looking from the extreme opposite position. (d)

> People tend to think of cures for stroke or heart attack, and they don't know scientific

details very well. (c)

The scientists saw that their role in the public sphere was to provide accurate scientific information, however, they did not explore further how they, personally, could contribute to enhancing public awareness. In Table 4, we present more data through the 'typical' case of scientists' claims from the viewpoint of H, doctor-cum-stem cell scientist based in a prestigious university.

Scientists' four claims exemplify the ways in which contemporary scientists make sense of the meanings of science in view of larger contexts. Next, we elaborate further scientists' ways of making meaning out of ethical scientific research, with the SCNT controversy as a case in point.

The SCNT controversy as a case in point

Popularly known as 'therapeutic cloning', SCNT is deemed to be a revolutionary approach to the generation of patient-specific embryonic stem cells that will open up a new paradigm of regenerative medicine. After Hwang's team failed to present one single stem cell line derived from somatic cell embryo clones in spite of using more than 2,000 eggs, the National Bioethics Committee delayed its decision to give permission to the same kind of research proposal submitted by the Cha Stem Cell Institute. In April 2009, the NBC decided to approve the proposal on the condition of further revisions: that they omit "treating diseases" from the research proposal to avoid raising people's expectations too high (communication), minimising the use of human eggs from 1,000 to 800 (bioethical and scientific issues), and re-organising the IRB for ensuring a quality ethical review (integrity and bioethics). The story of SCNT is then a relevant case that shows how four claims identified in the above section are actually justified in the real situation.

When asked about their views on the NBC's decision, the scientists focused on the scientific issue of the number of human eggs and tried to assess the scientific ground that the decision was based on:

> If there were already a success of the SCNT by other teams, reducing the number of eggs would be significant in the aspect of efficacy. However, at present nobody knows that it is even possible to derive cloned cells through the SCNT. I don't see any point in reducing the number itself. It is nonsense to me that using 800 eggs is ethical whereas 1,000 eggs is not. (a)

> Since the proposal already obeyed the law

Table 4
Examples of the scientists' claims on ethical issues

Claims	Typical examples
Bioethics is a matter of policy/social consensus.	• Stress on scientific evidence • Historical view of science.
Scientists are capable of knowing what is ethical.	• The Hwang scandal was not just about the team's misconduct but the lack of self-discipline within the entire scientific community in Korea. • Scientists should not be considered unethical just because their positions differ from the others' points of view.
Commercialism should be addressed.	• The value of basic science should be supported by policy. • There exist blurred boundaries between what is ethical and unethical in the clinical application of research.
The public should be well-informed.	• A scientific knowledge base takes the essential part.

in obtaining human eggs, they [the regulators] then contended the number, but there was no scientific ground in doing so. In fact, the scientific ground for using 1,000 eggs is also actually weak; it can still be argued, however, that the probability rate for success increases given the calculation based on previous experiments. Therefore, reducing the number could be a blow [to Cha researchers]. (I)

Whilst condemning the 'unscientific' issue in the NBC's decision, many scientists also stressed that a 'scientific' attitude is necessary, in this case, by keeping the scientific unknown, i.e. the viability of SCNT, open to debate:

> Even so [further revision was required], the fact that we reached such a consensus is a relief. I believe it showed our society had become more mature, but I am not sure about what the next step might be. I don't think they (NBC) will give permission to other teams, at least until the Cha team shows success. If the project eventually fails, they would then argue that it is only a waste of eggs, and I don't find this argument wrong from the scientific point of view, since I don't believe that scientists should be allowed to act freely as they wish regardless of the social implication of the research. (I)

To these scientists then, the ethical problem of the SCNT was concerned less with 'bioethics' the destruction of human eggs – but more with the feasibility of the SCNT as a scientific method:

> I think pursuing SCNT is reasonable for bio-techs like Cha. I also take the view that NBC's decision was reasonable. My only worry is that they mustn't rush things [to get the result so quickly]. Although I do believe ethics cannot dictate what science does, nevertheless, if their research is driven by a commercial interest, they [the scientists] cannot ask for total freedom. (S)

The SCNT method looks both doable for the scientists, however its scientific value must be considered carefully through the critical assessment. Overall, the scientists' honesty is considered necessary in making public the prospects of their research:

> Scientists are divided [over the prospect of SCNT]. What is known so far is that it is possible in animals, but not in humans. There is no evidence that it is impossible, nor that it is possible. […] My view is that their [Cha team's] claims are exaggerated. I would ask if Dr. X [the head of SCNT team] is really honest. (G)

All the scientists stressed the scientists' responsibility for scrutinising scientific issues and abiding by the ethical regulations, and believed that in this way, the value of scientific research can be achieved and upheld. In the next section, we elaborate further the ways in which the meanings of scientific value are constructed.

2. What is the value of stem cell research?

Stress on the 'basic research'

The scientists' descriptions of the purpose of their research were mainly concerned with either basic, theory-oriented type, or clinical, application-oriented type. This points to the very characteristics of the scientific and socio-cultural motivations directing the stem cell research. For example, for a biologist whose interest is mainly concerned with cell functions and the identification of hESC specific micro RNAs, human embryos are thought of as research materials, like other cells. In contrast, medical doctors placed great emphasis on the potential of stem cells in curing currently incurable diseases. However, as already emphasised in Result 1, the distinction between the scientific knowledge base that is already certified by scientists, and such potential, must be kept apart. Therefore, the medics also stressed the 'scientific value' of their research that is mainly concerned with increasing scientific understanding through discovering new facts.

Meanwhile, the scientists' differing research interests led them to select different types of stem cell in their research. For example, a biologist chose hESC lines to study cell functions, and he had no interest in deriving hESCs through the SCNT. Overall, the scientists' assessment of the value of different types of stem cells was based on their research interest and the state-of-the-art scientific debate. Even though all the scientists supported the permission for SCNT research, their belief in this type of research was only speculative: "It will increase our scientific understanding.", with little self-motivation: "I am not interested in this type of research." Then their assessment of the current research progress in the SCNT was rather cool-headed, especially dismissing the hype that still exists in the media concerning the potential applicability to curing diseases. Nonetheless, they claimed that SCNT derived cells and iPS cells are equally valuable materials in the case of studying reprogramming. No scientists asserted the necessity of the SCNT research without scientific grounds.

Fig. 3 shows one scientist's (post-doc, hESC focus) interpretation of the scientific value in terms of the NOS aspects (four parts in the circle and the grey colour boxes; the remaining boxes are related narrative segments.). By stressing the value of basic research, ethical concern about clinical, applied research becomes conspicuous. He also considered that the authentic scientific activities do not preclude subjectivity, but that it should be considered as enabling, not constraining, chances to scrutinise the scientist's interpretation of data. His concern and criticisms centered on the lack of cultural and policy support that encourages active communication and reflective practice that will eventually lead to the flourishing of a good scientific research culture.

Defining the scientific value of 'original

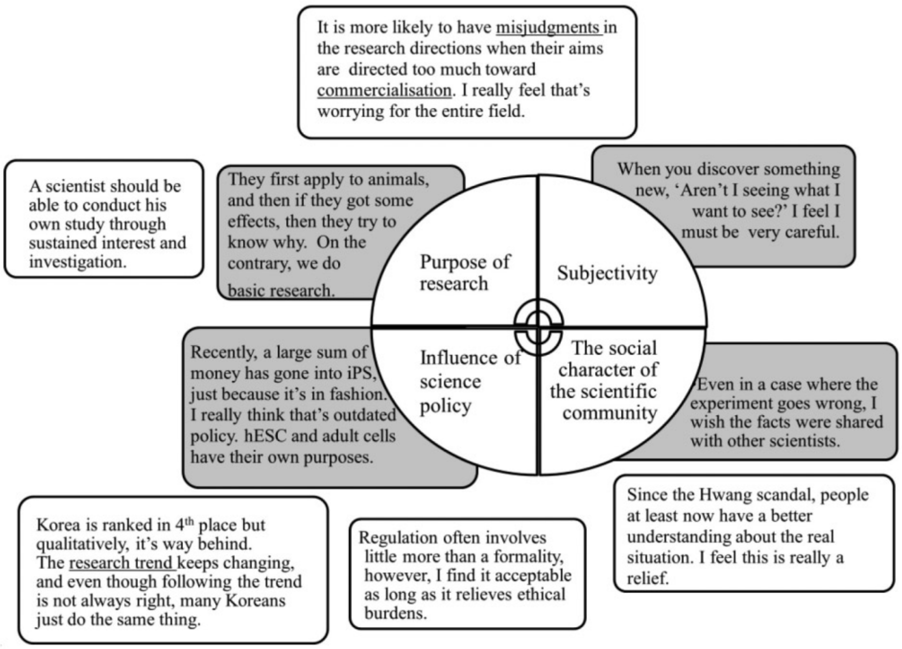

Fig. 3 *An illustrative case that shows scientists' notion of scientific value in relation to various NOS aspect*

technology'

The notion of 'original technology' is a useful example that shows scientists' discursive efforts to legitimate the meaning of scientific value. As shown in the scientists' sober assessment of the feasibility of the SCNT method, no scientists in this study could afford to claim so boldly about original technology. A senior scientist who became renowned in his research field stressed the 'basic, scientific' as opposed to the 'naive, clinical', as underpinning the concept of original technology:

> Nowadays no one considers an injection [of cells directly into the body] as [proper] research, and it only takes place in some underdeveloped countries, or certain small clinics in this country. It is because we have increasingly realised that an injection has only a limited clinical effect; and now it is acknowledged that without enhancing cell function itself there will hardly be any radical breakthrough in terms of cell therapy. This is the basic concept [of original technology]: beyond naive therapy and application, we're trying to develop core technologies that enable us to realise cell therapies. (C)

Scientists then found that there is a gulf between the scientific definition and public perception with respect to what counts as original technology, as in the SCNT case. One scientist explained why he felt frustrated when his 'original technology' was not easily transferable to ordinary language:

> …..but my research [micro RNA] doesn't sound fanciful to journalists. The item is difficult for them to write about, since it's not directly related to a cure. Since the funding body wanted some publicity, I had my paper covered in a short article, but then later, a TV reporter, who I knew personally, rang and asked me, "Why didn't you tell me about it first?" However, then he said he couldn't really understand what my research was about. I explained it a bit more, then he said, "I see, so it is not really fit for TV." I do understand him. What I am trying to say is that there is such a lack of interest in basic research, even among fellow scientists. The biggest problem for me is this gap [in the definition of 'basic' research]. These days, even doctors claim that they do basic research, and government officials have no ability to assess such claims. (I)

According to the scientist, the poor national research infrastructure, compared to Western countries or Japan was responsible for Korea's weak status in developing original technology:

> Developmental biology is the central part of RIKEN [in Japan], but the area actually covers all kinds of stem cells, from the basic to the applied. Look at this booklet. They all look happy and confident. They produce such high quality research papers. (I)

Reflecting on the current state of Korean science naturally led the scientists to their wish to achieve 'good' science, or a real breakthrough that often comes after long-term investments into high-risk approaches. In spite of many systemic obstacles then, pursuing the scientific value should be integral to scientists' attitudes and the enculturation process:

> I try to convince my students that scientists should be able to speak about the value of their research in front of the public. In the narrow term, they should be well aware that scientific research is operating through the social consensus and public attention that affects policy support, but broadly speaking, they should be able to grasp the bigger picture about what the area is moving toward, from more holistic and objective perspectives. (Q)

V. Discussion and Conclusion

1. Reflection in the scientists' stories and its pedagogical implication

This study explored scientists' ethical sense-making in terms of the ways in which ethical issues are identified and the meanings of scientific value are constructed. Their stories enabled us to look into the tacit dimension of everyday scientific practices and the process by which scientific knowledge is constructed. The socio-cultural conditions in which the field of stem cell research is situated the purposes of research becoming socially controversial and researchers in the field being faced with the increased pressure of regulations seems to become a force making the scientists actively pursue their identity and position in the social and policy debate process. Scientists' emphasis on the 'scientific value' of their research in arguing for certain ethical positions, or justifying the reasons why their research should be supported, reveals the elusive dimensions in the nature of contemporary science, more particularly in the nature of the 'science-in-the-making' process. At the same time, practical and systemic problems for cultivating ethical consciousness were challenged, such as infrastructure, outcome-driven science policy, poor working conditions and so on. The stories also revealed the social aspect of scientific research and the knowledge construction process whereby many actors and groups get involved in the process of making rules and normative values, so that the value of science is sustained and further enhanced. However, in the stem cell community at least, the scientists' capability of communicating with the public seems to remain very low, in spite of their claim that scientists are capable of knowing about ethical issues. This finding suggests that communication between science and society should be actively pursued by the scientists themselves, if they really wish to inform the public about the 'true' value of scientific research and knowledge (e.g. original technology).

The contribution of the study's focus on the scientists' views on the scientific practices can be found in relation to the ongoing concern with epistemologies of science and the nature of science in science education. The study's explicit focus on scientists' ethical sense-making and its relation to scientific identities led to the scientists' stories that brought to the fore what is involved in the reflective process of becoming a scientist in the contemporary era. Recently studies on the scientists' views of the nature of science also began to recognize the value of such reflective thinking part in shaping the epistemologies of science (Schwartz *et al.*, 2004; Samarapungavan *et al.*, 2006). Nonetheless, the inquiry foci in these studies lied in the identification of differences among the scientists with varying disciplinary backgrounds or professional experiences. In contrast, the present study highlighted that reflection is key in the scientists' sense making about ethical issues and the value of science.

But then what is the pedagogical implication of explicitly addressing scientists' reflections for science education? Based on the study's result, we propose a heuristic model that can be used to explore the place of reflection in scientists' stories in ways that invite readers to participate in the critical interpretation of the meanings of science (Table 5). The narrative framework in this study was developed based on the three parts: act, actor and reflection (Fig. 1), as an effective way to bring reflection process in the sense-making to the fore. The empirical findings of this study suggest that reflection indeed occurs, however variable the extent and qualities are among the participating scientists. The heuristic model includes narrative components suggested by Avraamidou & Osborne (2009), and the place of reflection relevant to each components. It can be used as a pedagogical tool with which teachers and students together make sense of what involves in the scientific identities both epistemic and socio-cultural, and comprehend the role of reflection in that process. By investigating narrative components of the stories in this way, students can begin to see and possibly learn the way in which a scientist reflect on the nature of science. Scientists' reflections on ethical issues and the value of stem cell research in the present study are one useful case story that can be further developed into a proper pedagogical storyline. The role of narrator (primarily, scientist(s), but also teachers or students from the third person's point of view) and reader (basically, learners) needs to be considered when applying to different pedagogical situations. In this way, various ways of reading and interpreting the stories can be made in communicating science.

2. Suggestions and implications

By developing methods of inquiry and analysing the scientists' stories, this study attempted to make a meaningful contribution to making science stories relevant to science education. Whilst the study's method was limited by using interviews only, other methods need to be developed in order to develop many different stories that can enlighten learners about the

Table 5

Reflection in scientists' stories: a heuristic model

Necessary components of a narrative suggested by Avraamidou & Osborne, 2009	The place of reflection in scientists' stories	Scientists' reflections in the present study
Purpose : To help us understand the human and natural world	• What is the purpose of my research? • What are social and ethical implications of the research?	Ideas about basic / applied research; Bioethics regulation and science policy.
Events : A chain or sequence of events that are connected to each other	• What are the significant events in the history of scientific discoveries in my research area? • What are the ethical issues arising from such scientific development?	First derivation of hESCs and iPS.
Structure : An identifiable structure (beginning, middle, end) where events are related temporally.	• What were the first reaction by the scientists and the public, what is the value now, and what will be the value in the future?	The value of iPSCs relative to SCNT; ethical issues of hESC vs. somatic SC;
Time : Narratives concern the past	• What is the meaning of scientific progress?	The therapeutic potential of stem cell research
Agency : Actors or entities cause and experience events	• Who is involved in the social decision-making process for resolving ethical issues? • What is the role of individual scientists and the scientific communities?	Conflicts among the different interest groups in the debate on bioethics regulation; The global science standard.
Narrator : The teller who is either a real character or alternatively a sense of a narrator	• A scientist expert telling a story about the key scientific ideas from a historical perspective • Other characters may include any individuals or groups on the lives of whom the science have major affects.	Fourteen scientists who were actively engaged in the stem cell research.
Reader : The reader must interpret or recognize the text as a narrative	• Students in science classroom • Science learners at various knowledge and interest levels	Not explicit, but basically non-scientists.

world of science and the scientific community in various ways. Also, the study only focused on what scientists say, not on how they communicate with the public. A practical suggestion would then be to develop a method of inquiry that invites scientists and non-scientists to partake of the opportunities for mutual learning, such as teachers, students and lay citizens, and engages both parties to reflect on the elusive nature of contemporary science in ways that enhance two-way communication about what counts as science.

Based on the study's findings, the implications for science education can be drawn in terms of how story-based learning facilitates students' enculturation in the practices of scientific culture. Firstly, future research is necessary in order to empirically examine the scientists' stories can be a useful tool for teaching that their reflections form a key part of the enculturation process. Through reading the scientists' stories, learners can be guided to explore the voice of the scientist who pursues the fundamental value of science and the goal of research, and by so doing, actively constructs scientific identities. Through meeting the authentic part of everyday scientific activities in this way, students can become more aware of science as a process, not just a product, and what is involved in that process. Such authentic stories expose the inter-relatedness of the epistemic aspects of scientific process with socio-cultural conditions. Also, a new type of scientist can be found beyond the heroic scientist model, by allowing the students to address both epistemic and practical challenges that scientists go through. Such a model can be helpful in enhancing the affective domain of science learning. In this way, we can promote epistemic practices in which scientists propose, justify, evaluate and legitimize knowledge claims (Kelly, 2007).

Secondly, more efforts are needed in order to encourage students to learn the importance of scientific norms in ways in which they can argue for what counts as science as in the scientists' 'claims' in this study. Importantly, learners need to be guided to be mindful that to do so takes reflective thinking about the nature of science. Focus on the questions of what constitutes ethical consciousness and responsibility in addressing socially controversial issues can be a complementary approach to the more cognition-based learning model related to scientific epistemologies, such as argumentation (Erduran & Jimenez-Aleixandre, 2008). This also suggests, for NOS learning, that merely to describe the definitions of the NOS is not sufficient, and that students need to engage directly with the sense-making process itself as scientists actually do.

Finally, more research is needed in order to examine whether students' critical thinking skills can be enhanced when engaging with scientists' stories. In the stem cell research case, student activities can include trying to define the scientific values in their own ways, such as the value of stem cell therapies, and comparing them with what is espoused in the media or the scientists. In this, students should be encouraged to make the distinction between science and non-science, but in a way that examines critically different assumptions underpinning what counts as science.

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Appendix. Key terms in stem cell research

(http://www.isscr.org; http://stemcells.nih.gov)

Key terms	Meaning	Scientific concerns
• Human embryonic stem cell (hESC)	A type of pluripotent stem cells derived from early stage human embryos, up to and including the blastocyst stage, that is capable of dividing without differentiating for a prolonged period in culture, and are known to develop into cells and tissues of the three primary germ layers.	Human embryonic stem cells were isolated in 1998. They are more difficult to work with than their mouse counterparts and currently less is known about them. However, researchers are making remarkable progress, learning about early human developmental processes that they otherwise cannot access, modeling disease and establishing strategies that could ultimately lead to therapies to replace or restore damaged tissues.
• Somatic (adult) stem cells	A relatively rare undifferentiated cell found in many organs and differentiated tissues with a limited capacity for both self-renewal (in the laboratory) and differentiation. Such cells vary in their differentiation capacity, but are usually limited to cell types in the organ of origin.	This is an active area of investigation. However, there are some big challenges that need to be addressed in order to use stem cells in treating a wider range of diseases in many patients: – an abundant source of stem cells must be found. – just as in organ transplants, a close match of donor tissue to the recipient is very important. – a system that delivers the cells to the right part of the body must be developed. Once there, the new cells must be encouraged to integrate and function in concert with the body's other cells.
• Somatic cell nuclear transfer (SCNT)	A technique that combines an enucleated egg and the nucleus of a somatic cell to make an embryo. SCNT can be used for therapeutic or reproductive purposes, but the initial stage that combines an enucleated egg and a somatic cell nucleus is the same.	This method has been shown to work for certain animals such as mice but has proven extremely difficult in humans.
• Induced pluripotent stem cell (iPSC)	A type of pluripotent stem cell, similar to an embryonic stem cell, formed by the introduction of certain embryonic genes into a somatic cell.	Embryonic stem cells and iPS cells share many characteristics, but they are not identical. The generation of human iPS cells was first reported in 2007. It is not yet completely understood how each of these reprogramming genes restores pluripotency; ongoing research is addressing this question. A great deal of work remains to be done before these methods can be used to generate iPS cells suitable for safe and effective therapies.