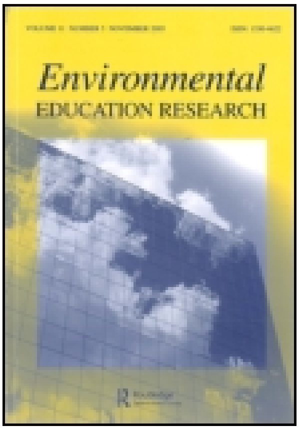

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Science, technology and the environment: the views of urban children and implications for science and environmental education in Korea

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Science, technology and the environment: the views of urban children and implications for science and environmental education in Korea

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With science and technology playing profound roles in mediating human relationships with the environment, a key question concerns which expectations and views of science and technology have emerged and prevail in visions of the social and environmental development of contemporary societies. This study engages this question through examining children's views of science and technology in South Korea. Eighty-six sixth graders from Seoul, a highly urbanized city, were invited to share their views. A drawing and writing activity and an open-ended questionnaire were administered for data collection. The study found that the children's views are grounded in optimistic and positive expectations and visions of science and technology even as some of the children show awareness and concern about environmental destruction. They may also offer contradictory views toward social development and environmental destruction. The paper discusses these findings in light of the complex meanings of development in modern Korean society and the challenges teachers there may face in cultivating sustainable views and relations via science and environmental education.

Keywords: STSE (science, technology, society and the environment); children's perception and drawings; modern culture

Introduction

Growing unease about the incidence and impacts of environmental degradation is widely understood to feed contemporary expressions of concern about the sustainability of contemporary lifestyles and their impact on the planet. However, while many environmental problems are increasingly studied in terms of the globalized nature of their origins and outcomes, the extent of their impacts and associated concerns about their nature are not always examined at the local or immediate level, including in terms of personal experience and viewpoints. South Korea, the national context for this study, for example, is witnessing widespread environmental effects flowing from increasing pollution and urbanization at local, national and regional scales; yet, it remains unclear as to how Korean people's lived experiences and actions regarding environmental quality are affected or even how that might inform and shape the science and environmental education taking place.

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This study attempts to offer some insights into these issues. It examines children's views of the environment within the context of a dwelled place and time, which, in this instance, is Seoul, a highly urbanized, modern city in South Korea. Given that engagements with science and technology are ever increasing, yet intimately related to our lifeworlds, it is important to understand how these might also contextualize and enframe people's interactions with their environment, not just at the level of theory, but also through empirical work. Payne (1999, 25), for example, argues environmental educators do well to understand ontology as 'a social phenomena about the underlying, often hidden, patterns and conventions of individually and socially lived experience' in order to sharpen their environmental educational inquiries. Doing so, it is argued, raises important methodological and epistemological questions not only about how environmental education experiences are socially and individually constructed, but also how their propensities enable a 'being for the environment', such that modern citizens might dwell in today's world in ecologically sensitive and technologically critical ways. Therefore, the study also considers how environmental and science education in Korea can interactively respond to the complexity of views and understandings, in order to foster sustainable rather than unsustainable relations.

The paper begins with illustrations of the views about science and technology in South Korea and how they might be associated with an emerging environmental sensitivity. Contemporary Korean society can express unease about the relationships between science, technology and the environment, even as it welcomes the contributions of scientific and technological endeavours to economic development and national standing. Scientific success stories are usually positive, popular and well accepted by the public; however, concerns about and the complexities and challenges wrought by science and technology are increasing and require more critical attention in current times, including in science and environmental education (Hwang 2009).

After setting out the background for this paper, I outline the research design for the study, followed by a presentation and discussion of the main findings.

Background

Science and technology have played a significant role in the development of modern South Korean society. After the Korean War in the 1950s, the first priority of the nation was to restore social and economic security. In an attempt to overcome the poverty and insecurity of the people in the aftermath of the war, the government started to focus on full-scale industrialization, promoting raw materials' extraction and processing, the introduction of advanced technology and science and engineering education. The development of science and technology was expected to revolutionize the industrial structure and thus bring forth the economic growth and independence at national levels (Koo 2007).

Whereas the new sciences and technological innovations were widely accepted and promoted as a key to development at industrial and national levels, they were also experienced by individuals in unique ways. Kim (2003) argues that Western science was mainly introduced through hygiene, medicine and machinery innovations, and it evoked powerful emotions among the public in the 1960s and 1970s. Kim observes, for example, that today's older generations can still vividly remember the time when Western soldiers first introduced dichlorodiphenyltrichloroethane (DDT) into their villages. Even if the insecticide was proven to be dangerous and inappropriately applied later on, the legacy of the mechanical and systematic application of this 'white powder' is largely understood as one where it came to be widely regarded as a great scientific innovation, in that it saved many villagers from itchiness, sleepless nights and disease. Indeed, it left a powerful image of science in many people's minds: that of science having the power and authority to shape human life and social development (Kim 2003).

More broadly, Ziman's (2000) account of 'real science' sets out to distinguish such examples as to whether they are cases of authentic forms of science and technology from that which might be regarded as 'scientistic' expressions. The latter have been an important factor in the philosophy and politics of Western forms of civilization since the rise of modern science in the seventeenth century. Based on the objectivity and authority of scientific knowledge, modern science and technology have become a means, as well as an ends, to achieving progress in individual and societal living conditions by helping humans utilize and transform their environments (Bowers 2002; Rees 2002). In the case of Korea, the uncritical promotion of science and its benefits was widely practised and prioritized in the unique historical circumstances of rehabilitating Korean society after the War. Kang (2008) reflects that at national and individual levels, science and technology were widely deemed to be the necessary tools to ensuring industrialization, social reconstruction, and human welfare for the decades to come.

Yet as the economy and post-war social structure developed, new challenges emerged in Korean society associated with the development and application of science and technology. Industrialization and urbanization were often coupled with these and served to variously challenge and change people's lifestyles, values and traditions, as well as their relationships with the Korean environment. According to Koo (2007), South Korea has aimed to build 'one large middle class society' (1) with certain economic standards and a high level of sophistication in consumer lifestyles. The particular ideal for this version of the middle class is marked by a wide range of largely consumerist behaviours, typified by consuming global goods and services, but might also include purchasing organic products or drinking purified water in urbanized environments. When environmental problems and health concerns such as air pollution and epidemics broke out in the early 2000s, people's expectations of middle-class lifestyles became more concerned with health protection and security, supported in the main by scientific and technological methods. Koo (2007) documents how one way in which people hoped to maintain the quality and safety of their living conditions was by consuming numerous scientifically proven, cutting-edge technological products and facilities such as modern air purifiers or exercise machines 'in a super-technically controlled indoor environment nicely separated from the noisy and polluted environment outside' (10).

As Grove-White (2005, 23) has argued, science tends to be enlisted in supporting a largely materialist orientation to contemporary industrial and post-industrial forms of society even as this might be controversial in promoting the notion of 'science-derived innovation … [for the] country's material prosperity and competitive trade position'. The twinned 'eruption' and 'pursuit' of science and technology in Korea have also become complexly intertwined with economic growth and consumption behaviours in people's mindsets and action over recent times, particularly as the growth of urbanization and consumerist lifestyles has created further challenges for natural resource and energy management (Kim 2003). For example, with a high population and limited resources,[1] sustaining lifestyles with high levels of resource and energy consumption has highlighted economic and environmental issues to do with energy production, supply and sovereignty. According to the 'Report on changes of environmental quality in Korea', more than 90% of energy in South Korea depends on imported energy resources (Park et al. 2006). To overcome this shortage in its own supplies and dependency on external supplies of energy, the nation has embarked on a nuclear reactor programme to generate electricity. More than 40% of electricity is now generated by the 14 nuclear reactors operating now, and more reactors are planned for the near future (Hwang et al. 2003).

While the merits and risks of using nuclear energy to meet increasing levels of energy consumption for economic development continue to be debated nationally and internationally (notwithstanding more recent discussions about the role it might play in reducing the nation's carbon emissions), radioactive waste management issues have become a serious concern amongst the Korean public (Kim 2006). According to the Korea Institute for a Sustainable Society (Park et al. 2006), the government and nuclear energy sector continue to try to convince urban citizens to embrace nuclear power by presenting the benefits of nuclear power, the safety of waste management facilities and the possibilities for compensation. But as the Institute notes, surveys suggest that citizens still do not want to jeopardize their lives or the future with the possibility of an undesirable radioactive environmental disaster, and thus debate continues as to whether nuclear energy will ever be regarded as a safe and 'green' energy route for urban and rural communities in Korea into the future.

To summarize, the aforementioned examples illustrate how the materials and methods employed by modern science and technology in industries and for the economy have strong cultural dimensions and cannot be treated as separate from other factors in decision-making about current environmental challenges. The situation requires Koreans to take into consideration the sometimes complex, mutual and tensioned relationships between human and environmental values and the practice and desirability of a science and technology-based future for the Korean economy. Pointing to the conflicts between scientific strategies for economic development and environmental destruction, Hong (2008) argues that it is timely for Koreans to consider the ways in which public and school education might foster reflection on the complex and interrelated relationships between science, technology and the environment. South Korean cities are growing, and the lifestyles and landscapes within these cities are rapidly changing through industrialization and urbanization. Children are exposed to urban, technological ways of living such as high-energy-consuming materials, indoor activities, network devices and so forth. Since engagements with science and technology continue to increasingly mediate everyday decision-making and actions, it is also important to consider how science and technology are understood, can be taught as well as practised in helping to resolve our environmental challenges.

With the current concerns of science, technology and the environment in modern South Korean society as they are, this study investigates children's views of the environment in relation to science and technology. Barratt Hacking, Barratt, and Scott (2007) emphasize that children's subjectivities and experiences as present and future citizens need to be present in the discourse of environmental education. They indicate that children in different societies and cultures portray different views, decision-making and actions regarding the environment; thus, their viewpoints and concerns need to be explored in relation to their own contexts. By probing South Korean children's views and expectations about their future environment, the study explores the substance and aspects of the complexity of their views on science, technology and the environment, concluding with reflections on these in terms of how this might inform science and environment education in Korea.

The study

The participants

Eighty-six sixth graders (44 boys and 42 girls, age 11–12) from two classes in a public elementary school in South Korea were invited to complete a multifaceted activity, comprising drawing, writing and, on occasion, interview phases. The school is located in an urban residential area, noted for its high-rise apartment complexes, condominiums and townhouses. Most of the students live in apartments or townhouses. Their everyday environment is very densely populated and urbanized. Such conditions are typical of much of the city of Seoul, with a population of about 11 million people living in 600 km^2.

The socio-economic status of the school and surrounding neighbourhood is categorized as middle class. According to their teachers, the students have relatively stable home environments, are well resourced for school life and have internet access and many other high-tech and modern convenience items at home. More than two-thirds of the participants were born in Seoul and have never lived outside the city. Indeed, to the casual question, 'What is environment?', the majority of children (over 80%) wrote that it was natural sites such as mountains, rivers or the ocean, rural places such as where their grandparents live and so forth and that they 'visited' the environment once or twice a year. A few children said they hardly visited any natural sites.

The school represents a convenience sample for two reasons. The school was close to the researcher's neighbourhood, thus it was helpful to visit the research site and to understand the children's everyday lives and environments. Also, a few of the teachers were former colleagues of the researcher, presenting further opportunities for deeper understandings of the context of the school and students. I wrote down observations, reflections and information given by the teachers about the children and school in a reflective journal throughout the study. This also became a valuable source for data interpretation and further discussion. The sample size was relatively small (n = 86) and from one site only. As such, the study is a modest attempt to reflect on a group of children's views of science, technology and the environment growing up in an urban place, and findings must be interpreted with these considerations in mind.

Research design

A drawing activity combined with writing and discussion and a questionnaire were used to probe children's views and understandings of science and technology in relation to the society of the future and the environment.

Drawing and writing activity

Drawings are widely assumed to reflect children's thinking about, and the interactions between, their inner and outer worlds through the medium of visual communication and representation (Kress and van Leeuwen 1996; Matthews 2003). As such, drawing has been useful for psychologists and educators to access and represent children's emotions, perceptions and experiences of their worlds (Matthews 2003; Ring

2001). Recently, deconstructing the traditional views of children's drawing as visual references to objects and thoughts, researchers such as Cox (2005) and Brooks (2009) have argued that drawing offers a visualization process for children's thinking, meaning-making and communicating within social and cultural contexts. Brooks (2009) identifies two dominant discourses of drawings for data gathering, one derived from the framework of children's cognitive development and the other from aesthetics, yet argues that neither explains the meaning-making process in which children are socially and culturally contextualized. According to Brooks, this is because the interpretation and analysis of drawings based on a cognitive developmental framework (as a spectator, for example) cannot adequately address the intentions of children or the social–cultural context in which the drawing took place. Furthermore, the aesthetic framework may have little to do with real world problem solving or meanings that are inherent in the drawing process. Brooks points out that while drawing, children absorb, assimilate, re-examine and transform their experiences and information about the world in interactive modes; therefore, our understandings of children's drawings need to look into how ideas are expressed, integrated and developed, based on topics, themes and contexts. In this regard, drawing can also be understood as an enactive process of learning, meaning-making and transforming ideas and perspectives, not only a method or product of expression or the representation of objects and thoughts.

In this study, drawings were used as the main data-producing tool to encourage children in urban settings to ponder and express their views about and expectations of science and technology for their future society. Based on their drawings and interpretations and discussions of them, the study attempted to uncover their views of science and technology in relation to social and environmental contexts and to develop pedagogical reflections on the findings. However, there are limitations when employing children's drawings as a research tool. Two will be discussed here. First, procedurally, a drawing task is not appropriate for children who are uncomfortable with expressing themselves through this means or who lack sufficient drawing skills and thus get discouraged by this approach. Therefore, there is a need for researchers to engage in thoughtful encouragement so as to build the children's 'comfort zone' and enable them to freely adopt alternative methods of expression. Second, methodologically, interpreting or making claims about children's views only from drawing data is problematic. Matthews (2003) points out there is a possible dichotomy between intellectual and visual realities in children's drawing; in other words, there may be a disparity between what they (might/can) express in the drawing and what they think or know. Also, children's views and meanings as represented in their drawings may be complex and still under development. To mitigate the danger of misinterpretation, researchers, such as Bowker (2007) and Leonard (2006), suggest incorporating further alternative activities, such as meaning-making tasks, talking and drawing, write-up exercises or follow-up interviews when drawing is used as the principal method for producing data. In this study, to reduce children's discomfort with drawing, the children were given the opportunity to choose to write instead of draw if they did not feel comfortable. It was also emphasized that they did not have to concentrate on the aesthetic aspects or techniques of drawing. All of the children chose to draw and some drew one or two simple objects and wrote their ideas around the objects. Follow-up activities such as writing and conversation about drawings were also employed to diminish misinterpretations or over interpretation.

The 86 children were asked to create drawings based on the following question: 'What would your future surroundings look like with advanced science and technology?' The children were encouraged to choose any style of drawing (i.e. individual items, scenes, labelling, etc.). Whilst they were drawing, they were encouraged to mark items with arrows and compose a brief explanation of that aspect of their drawing. The drawing activity was followed by interviews and group discussions after one or two weeks. The range of activities provided children with an opportunity to reflect on their own views and their processes of meaning-making in regards to science, technology and the environment together with their peers. It also helped the researcher to understand the children's intentions and the meanings they ascribed to their drawings and annotations more closely. Twelve children volunteered for group discussions. Among them, five children participated in individual interviews. The interviews and the group discussion lasted for about 30 minutes each. Children explained their drawings to their peers, asked each other questions about the drawings and responded to the questions. The researcher also participated in the group discussions, intervening only minimally to encourage them to talk or to ask questions about their drawings, for example, 'what would happen here?' or 'can you elaborate for us?' The conversations were recorded with audio recorders and transcribed for data analysis.

Questionnaire

I also administered a questionnaire with two open-ended questions to probe how children viewed the relationship between science, technology, society and the environment (STSE). This questionnaire was given to the children after the drawing and writing activity and before the interviews and group discussion. The children ($N = 86$) were encouraged to write answers to the following questions: (Q1) 'Do you think science and technology is necessary for our society and nation? If so, why? If not, why?', and (Q2) 'How does the development of science and technology impact on the natural environment?' All of the children's responses were used to interpret the themes underlying their views and understandings of science and technology in its current and possible future states.

Data analysis procedures

The data were analyzed both quantitatively and qualitatively. Peer discussions and a debriefing process were used to share the raw research data and test tentative interpretations (Lincoln and Guba 1985): firstly, with an elementary school teacher who was the homeroom teacher at the research site, and then with a university instructor working in the field of education.

First, the teacher and I looked at the children's drawings separately and then shared our possible interpretations of individual drawings and annotations. Items and phrases depicted in the children's drawings were taken as the unit of meaning and categorized into the following initial 10 topics based on their frequency of occurrence: *communities in sky level (e.g., high-rise buildings), flying vehicles, communities undersea, robots at home/workplace, computerized places, space science, living on another planet, pollution, violence (e.g., vanishing humanity or war and armament)* and *laziness*.

As the unit of meaning was an item or phrase, and not the whole theme of the drawing, some drawings were coded with more than one topic. For example, if a drawing depicted a person using a remote control to manage robots at home and was accompanied by an explanation that 'this would increase the level of laziness and have a negative impact on our society', the drawing and text were coded with both the 'robots at home/workplace' and 'laziness' codes. In coding some items (e.g. robot, spaceship), there was not much difference in coder attributions; however, in coding the topics for each drawing (e.g., communities in sky level, space science), there were differences. This was because some drawings included several different ideas and ambiguities. We discussed and chose more than one topic when we agreed themes were equally distinctive. For some drawings though, we could reach one distinctive theme after discussion, while for other ambiguous elements, we also clarified the meanings with children.

Throughout the coding process, the data from the interviews and group discussion were also shared to help develop possible interpretations of the children's drawings. Because the children had opportunities to explain their drawings during interviews and discussion, the verbal data were also useful for deepening our understandings of the meanings and intentions associated with the drawings. Through the sharing and discussing of our impressions, we strived to reach integrated and comprehensive interpretations of the children's drawings and ideas. I later invited a university instructor to look into about 30 drawings randomly selected and about 15 drawings over which the teacher and I had some initial disagreement. She attempted to code them against the coding schemes that I provided, and later we compared and discussed our interpretations together. During this process, there was also some adjustment of the topics against the coding scheme, but there was no significant change in the framework of data analysis at this point. When our inter-coder results were more stable and integrated, the 10 topics were then aggregated into the following categories. The themes were developed by focusing on the spatial boundaries that science and technology could effect in the future:

(1) residential areas in terrestrial space (e.g., communities in sky level, communities undersea, flying vehicles, etc.),
(2) living/travelling in extraterrestrial space (e.g., spaceships, space stations, living on another planet, etc.),
(3) innovative home and workplace environments (e.g., robots at home/workplace, computers, other advanced devices, etc.), and
(4) others (e.g., violence, vanishing humanity, laziness and destroyed earth).

The responses in the questionnaires were also coded, counted and quantitatively analyzed. In this process, the teacher worked with the researcher to interpret and categorize the children's responses. As with the drawing analysis, if a child's answer mentioned more than one topic or idea, each one was counted separately. For example, if a child answered 'cars and highway construction' as the cause of environmental destruction, 'cars' and 'highway construction' were coded and counted separately (see Table A2 in Appendix). Hence, the number of responses is greater than the number of children. After being coded, a count of the responses was made to provide an overview across the children of their understandings of STSE relationships. The children's responses were also qualitatively examined, in line with the narrative elements that surfaced from the drawing and writing activities, to explore the complexity of their understandings of STSE relationships.

Findings

An optimistic vision of the future of science and technology

The children had been invited to draw what they imagined a future society would look like, with advanced science and technology. Most of the children in this study prepared drawings showing that science and technology would enhance resources, promote efficiencies and further the convenience of human lifestyles and living conditions. Among their drawings, 33% depicted residential areas in terrestrial space (including communities with high-rise buildings and roads, flying vehicles in the sky, communities undersea with submarines as modes of transport), and 30% drew innovative home and workplace environments (including house robots, computers and other advanced devices). Twenty-three percent of the drawings were about living and travelling in extraterrestrial space (including spaceships, space stations, living on another planet), while the remainder (14%) focused on other themes (such as violence, pollution, vanishing humanity, laziness, an Earth that had been destroyed) (see Figure 1). In the 'others' category, the children explicitly included negative concepts in their drawings and annotations. Examples include 'the air will be too polluted in the future' or 'science and technology will develop nuclear weapons. It is too dangerous'.

The topics and scenes in their drawings might be familiar, given there are many examples of optimistic and utopian images of a science- and technology-based future presented through the media in South Korean society, including in science magazines, exhibitions at science centres, movies, cartoons and games, news or commercials. Children could also be exposed to those ideas over time, thus their drawings could be argued to be a snapshot representation of their experiences and imaginative responses to these images given the task at hand. In this regard, the topics in their drawings could explain how children's ideas and views come to embody the social assumptions and expectations of science and technology.

In looking to the future, most of the children's drawings represented science and technology as changing and expanding the landscapes for living and dwelling to unknown and unreached places. By imaging space and under the sea as alternative places to live, the children expressed excitement about the options they foresaw as future habitable environments. Also, the engagement of machinery and technological enterprise was another noticeable topic in such future environments. Flying cars, house robots, computers at work and the technology of spaceships were used to

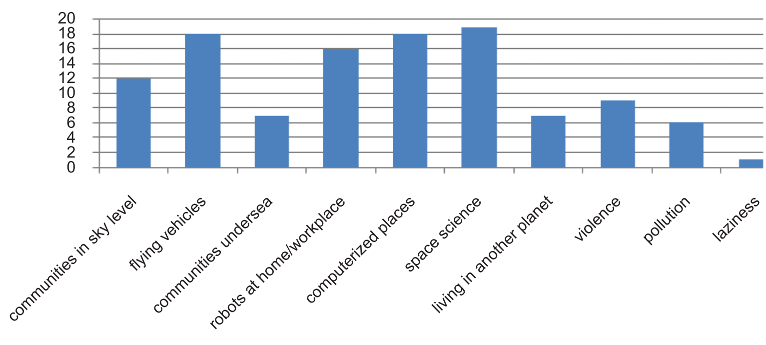

Figure 1. Categories of children's responses in drawings and writings (total = 113).
Note: The total number of responses exceeds the total number of children because some of their work was coded by more than one topic.

illustrate changes in living conditions and habitable possibilities. For many children, science and technology seemed to be a means of developing efficiency and convenience in life and overcoming the limited boundaries of the present environment.

Coupled with this, some children also illustrated how science and technology could alleviate concerns about overpopulation and lack of resources. Drawings expressed utopian expectations of science and technology, and the discussions illustrated their excitement about innovations. Han (boy, age 12), for example, drew a picture of a sky city and explained that advanced science and technology would help humans build a city in the sky to overcome overpopulation and garbage pollution (see Figure 2). He expected science and technology to help humanity build a safe and convenient space to live in the future – much like his existing lifeworld but transposed skywards.

Jun (boy, age 11) adopted the idea of cloning to solve the problem of land shortage (see Figure 3). His drawings depicted the wholesale cloning of Earth, with people being moved to the 'new Earths' via special movers.

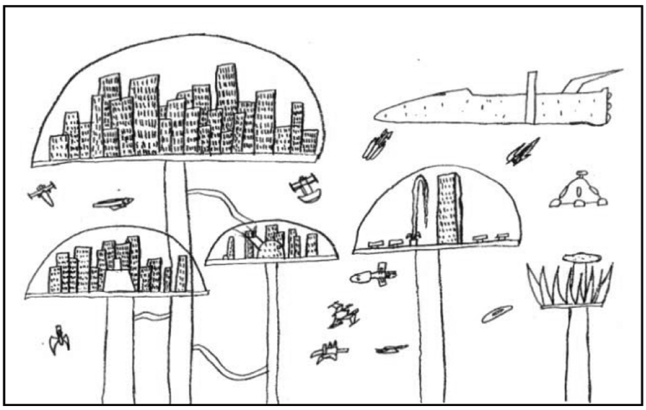

Figure 2. Han's drawing.

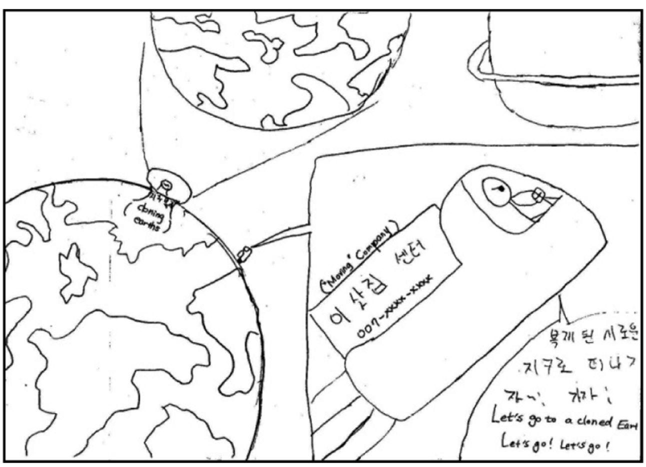

Figure 3. Jun's drawing.

Jun wrote:

> I came up with the idea of cloning. We could clone Earth and move to another earth when our lives would be in danger in the future. Or move to another planet. We would be able to move to another planet with the development of science and technology.

The image of cloned Earths could be understood as implying the wish to find unknown but as yet unavailable places where humans could then live; this is again, though, strongly indexed to existing lifeworlds. In fact, in the interview, Jun clarified that he saw science and technology as a means for helping humans find other better places to live, even though he had presented only cloned versions of the here and now.

During the interview, utopian and innovation ideas were also discussed in relation to the children's everyday experiences. When a landfill project on the west coast[2] was mentioned, some children indicated that science and technology could be used to create and construct more land and habitable spaces for future human needs. Some also mentioned news about the conflicts surrounding nuclear waste management facilities in a city in South Korea and wished there would be more advanced knowledge and skills in science and technology to build safe facilities around the region. Thus, science and technology were largely regarded as powerful and positive: they could help people overcome human limitations, help solve challenges in current society and assist in building a convenient, secure, even spectacular future for humanity.

Anxiety over environmental destruction lurking in the background

Reviewing children's drawing topics can offer insights into their interests and hopes for the future of science and technology in their surroundings. Given that more than half of the drawing themes (56%) depicted future surroundings outside of or beyond their current living environments (such as in sky cities or space), the children were encouraged to explain what they hoped to achieve through advanced science and technology and why they enthusiastically hoped for these currently unavailable relocations or places (even as they reproduced a highly urbanized and industrialized logic). Their curiosity and excitement about mysterious places, spaceships, robots or computers was acknowledged, and, yet, there was some degree of concern for their future society and the natural environment in the midst of the confidence and excitement they expressed. More than one-third of the children's drawings and writings included an image or phrase voicing concerns or anxieties over environmental destruction – natural environment, rather than urban. For example, expectations of shortages of land and the effects of environmental pollution, destruction and desolation also inform Han's and Jun's hopeful images.

The following is another example of how this concern was expressed. Cojin (girl, age 11) felt happy that science and technology would keep her safe in a future environment (see Figure 4).

She wrote that 'people will need to carry oxygen tanks to breathe safely. There will be more air pollution in the future. Science and technology will help us solve it. I can walk my dog by getting him an oxygen tank too'. In the drawing, she has an oxygen tank and a happy smile. Although the air is polluted, she explained, she can still feel safe, secure and happy with the oxygen tanks for herself and her dog. Another drawing by Hyun (boy, age 12) suggests a similar idea (Figure 5).

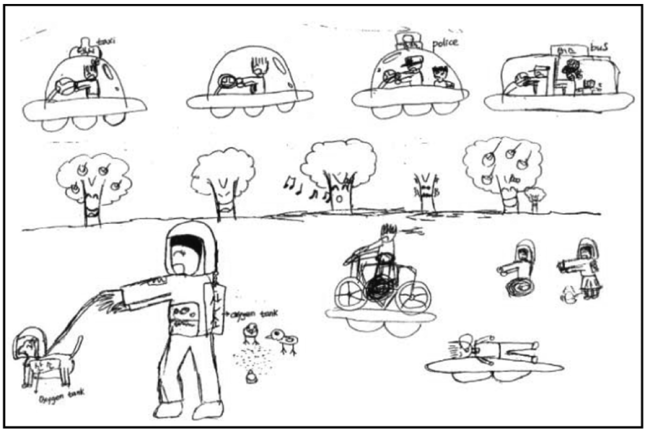

Figure 4. Cojin’s drawing.

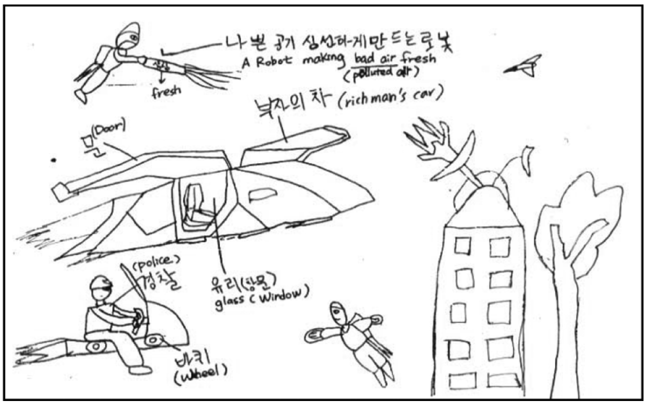

Figure 5. Hyun’s drawing.

He wrote ‘there will be robots for treating air pollution’. In his drawing, anthropomorphic flying robots are used to clean the polluted air he expects in the future. These are accompanied by flying vehicles belonging to the rich and the traffic police. Although Hyun does not address the consequences of fuel consumption in either case, he does expect that advanced technology could be used to protect or enhance the quality of the environment he views as a risk in the future.

Environmental destruction relative to the development of society

In their accounts of their views and understandings of the relationship between science and technology and the environment, the children often expressed their hope that the advancement of science and technology would bring about a better future, with improved living conditions, a strong economy and nation and a technologically advanced world. The majority of children (94%, n = 80 out of 85) agreed that advances in science and technology will enable the development of society and nations. However, an almost similar proportion (87%, n = 75 out of 86) said that the development of science and technology negatively affected the natural environment (see Tables A1 and A2 in the Appendix for details). The children further indicated that environmental problems might be inevitable by-products of economic growth and technological progress by saying 'scientific development is important but the development for us disturbs nature greatly' (boy, age 11) or 'we cannot avoid a little bit of environmental destruction in order to become a strong nation' (girl, age 12). Environmental sustainability or balance was not recognized as a key objective of social and national development in some children's understandings.

The children did view scientific and technological developments as leading to the development of society, particularly in terms of the availability of high-tech conveniences and economic affluence. Yet, scientific and technological development causes environmental problems, which for them seem to be unavoidable. They also expected science and technology to be at hand to solve some of these environmental challenges. Hence, they view science and technology as a cause of environmental problems, as well as a means of solving those problems.

Discussion

An uneasy relationship between science, technology, society and the environment

Studies of children's awareness of environmental degradation have been conducted in many different parts of the world. For example, Barraza (1999) used drawing methods to probe children's understandings of the environment in Mexico and England and found that children were aware of environmental problems and often became pessimistic about their future. Korhonen and Lappalainen (2004) show how children in rural locations in Madagascar show concern about local forest destruction. Reviewing a range of recent studies on children's views on the environment, Hicks and Holden (2007) point out that the natural and urban environment has been a consistent concern for children across today's world, and they anticipate many problems in the future, such as a loss of a place to play, deforestation, pollution, traffic and industrialization.

This study adds to this literature on children's concern over the environment in an industrial, urbanized place. In the findings, most of the children's drawings depict their excitement regarding the society of the future in terms of the development and application of science and technology. As science and technology advance, living conditions are expected to improve and social development be enhanced, modelled largely on the present. However, despite their enthusiasm and wishes for economic growth and technologically developed environments, they also expressed concerns about its negative outcomes, specifically environmental destruction due to overexploitation. Interestingly, a few children in this study started to mention the unequal access to and distribution of the benefits of science and technology between the rich and poor. For example, in Hyun's drawing, he drew a flying car and marked it as a 'rich man's car'. During the group discussion, children explained that science and technology would benefit the rich more because the poor could not afford to buy either the skills or products.

Some of the children and adolescents in the Madagascan study also saw a conflict between economic purpose and environmental degradation. Korhonen and Lappalainen (2004) note that they recognized poverty and poor education and training as major causes of environmental degradation along with other more direct causes such as deforestation and charcoal burning. To remain economically independent and strong, villagers might be forced to destroy their local forest to survive, such that the environment then became primarily a resource and a commodity for trade. Resonating with their research, this study also indicates there can be complexity to environmental concerns in relation to the expression of social values and expectations at the local level. The Korean children's experiences and concerns about the environment were primarily tied to economic values and social changes. In the children's conflicted understandings of science and technology-based development, the level of social development depends on economic and technological indicators, and the quality and harmony of environments were hardly taken into account. They appear to concede that some degree of environmental degradation and the exploitation of natural resources would occur as a result of social development. And as the children mentioned in relation to issues associated with the nuclear industry, landfill projects and pollution, they were also aware of current social and environmental issues in the public domain. Yet, some were also able to reconcile their awareness and concerns with an expectation of new knowledge and skills in science and technology, the importance of economic growth, its economic benefits and environmental exploitation. In this instance, the meaning of development was very much driven by materialist, anthropocentric values and a focus on the tools of science and technology, without taking into consideration a planetary sustainability paradigm, which might seek to harmonize human needs, desire and the capacity of natural systems. Environmental values, equity and limits did not appear to be part of these children's criteria for 'development'.

Mander (1996) and Losh, Wilke, and Pop (2008), indicate that children, today, are exposed to, digest and come to embody complex and incoherent social and cultural phenomena, often through various images in the media which propagate the principles and desirability of high-technology lifestyles into younger minds. These stand to frame their understandings of the relationship between science, society and the environment and sometimes form stereotypes of certain concepts and relations. This notion raises a question of which images and values of science, technology and social development are embedded in current South Korean society, and, furthermore, how these images and values might influence children's thinking about, and representations of, the complex relations of science, technology, society and the environment.

As noted in the background, for many decades, science and technology have been prioritized as the key to Korean development. Longing for the culture of the Westernized middle class and its associated sophisticated lifestyles, science and technology are expected to help build better lives towards these ends. And yet, as Korean society has become industrialized and urbanized, these expectations go largely unchallenged, and the expression of hope for a better future becomes largely entwined with the view that it is about the consumption of goods and services in the public's understanding. Rees (2002) explains that modern cultures have developed the myth that human welfare can be equated with ever-increasing material well-being; thus, the degree of a society's development depends on pursuing material values. Modern technology and science genuinely contribute to progress in life by making it more convenient and materially and technologically rich, while, in the process, strengthen the boundaries between human society and the natural environment (Wackernagel and Rees 1996; Wilson 2002). Harris (2000, 3) also writes that 'we tend to equate science with civilization itself, considering peoples who lack it, or are scientifically unsophisticated as, to that extent, uncivilized, and those who enjoy its advantage as the most advanced'; while Rees (2002) argues this common ideology transforms decent, well-rounded citizens into adopting an anthropocentric pattern of thinking that reduces nature to an exploitable resource.

These notions have especial resonance in contemporary South Korean society. Kim (2003) indicates that in South Korea, as a recently urbanized and industrialized nation, the ideals of development and progress are closely linked to economic and technological progress and Westernized forms of civilization. To cater to the demands of the myth, people have strived to find ways to produce and obtain more goods and services. Recently, material goods and technologies have become the definitive indicators of social development. To keep up with changes in the world, South Korean society has eagerly restructured its figures, systems and values, so as to progress more quickly in the era of globalization (Koo 2007). In this context, science and technology have become the cornerstones of economic growth predicated on the manipulation of natural resources. However, a critique of the alliance between society's consumeristic values and science and technology is emerging, which recognizes that rebuilding ecological harmony between humanity and nature is critical for a sustainable future.

With these social phenomena, children have already experienced the contradictory ideas of development and the insecurities of a scientific and technological revolution. There is the distinct likelihood that the values and views of science and technology, social development and the environment have been projected, encountered and, in some cases, internalized by children through exposure to their dominant social representations. Living in this complex society, children experience, learn, grow and become citizens of society in a world where only particular views of development, science, technology and the environment become pervasive and embedded in the media, culture and mindset. Children are exposed to and may uncritically adopt what society values into their understandings of the world and the future, particularly through its educational institutions. The dynamic social values and binary understandings of the environment might have contributed to children's conflicted views of science and technology. These lead us to question what type of worldview Koreans value, what Koreans are concerned about as a society *per se* regarding scientific and technological development, and how science and environmental education can respond to this.

However, before discussing children's views and social assumptions further, it is understood that this study has limitations. As mentioned earlier, the sample size is small and limited to one school in one location. Also, it was conducted in an urban setting where science and technology have rapidly changed social and environmental systems, features and values. In addition, the question the children were asked to respond to was specifically focused on how science and technology is related to their surroundings in the future. Thus, children's understandings of the environment were focused on man-made, techno-scientific worlds, not necessarily more naturalistic domains. These two features of the study imply that its findings and interpretations cannot be easily generalized to other societies and cultures, especially those that are very unlike urban South Korean lifeworlds. Despite these limitations, the study can contribute to discussions of children's views and concerns about the environment and understandings of, for example, sustainable development in conjunction with the findings of previous studies.

One important agreement across them is to recognize that children's experiences and views on the present and future environment have positive as well as negative elements whether they live in rural or urban or developed or developing countries, and there is a need for pedagogical reflection on the complexity of their concerns. Children's experiences and concerns are lived, complex and socially contextualized in their own place and time, which, in this case, is in a society experiencing rapid changes due to industrialization, urbanization and consumerism.

Thoughts on science and environment teaching

As the world continuously develops and deploys science and technology in our social and environmental systems, we need to simultaneously study how such knowledge and practice interfaces with a healthy ecological framework of human–nature interactions. We also need to consider how science and environmental education encourages children to understand the meanings of sustainable forms of development and participate in scientific and technological decision-making and actions with sound relationships to their lifeworlds. Taking into consideration the role of science and technology vis-à-vis environmental issues, science educators have discussed how science education can respond to the growing concerns about the environment and the role that scientific knowledge might play in regard to ensuring a sustainable future. For example, Dillon (2002) argues that we should 'shift from seeing "environment" as a focus for the consideration of science concepts to seeing a science education as one that seeks to help students understand environmental issues in the context of their lives' (1112). Colucci-Gray et al. (2006) also emphasize the importance of controversial socio-environmental issues in the science curriculum in order to connect students' scientific knowledge and skills to real-life situations, and hence to learning about the possibilities and practices of democratic, creative processes of problem solving in complex situations.

Even if the postmodern paradigm has attempted to embrace affective and cognitive features of science and knowledge in science education (Littledyke 2004), the dominant positivist view of scientific and technological knowledge, i.e. an objectified and value-free paradigm, still remains the mainstay of science education in Korean society. Yet, by teaching the environment as a concept in biology or ecology with the focus being on the components of ecosystems, scientific knowledge of the environment risks becoming fragmented and compartmentalized into empirical evidence and technical solutions (Barrett 2001). This approach to teaching science risks presenting scientific knowledge as value-free or value-neutral and avoiding issues such as the impact of human actions, social issues or technological engagement in the environment. Moreover, this mechanistic knowledge and approach to science, technology and the environment is by itself insufficient for effective problem solving in real-life environmental issues (Eilam 2002; Korfiatis 2005). Slingsby and Barker (2003) discuss how mechanical approaches to scientific knowledge lead many students to think of environmental science or biology as only 'a secure framework of factual knowledge in which knowledge is applied in clearly defined contexts' (5). In this regard, students' knowledge could be presented and applied in textbook-oriented or test-driven problems in classrooms; however, it often remains isolated from the complexity of lifeworld and the subjectivity and complexity of human experiences and identities (Hwang 2009). Criticizing analytical technical concerns of 'accurate knowledge' or 'misconceptions', Gough (1999) emphasizes the inclusion of human agency and subjectivity in the discourses of science and environment education. He argues that 'those of us in environmental education research who have taken up and been shaped by scientific discourses of environment and education need to come to a self-critical understanding of how we are constituted by these discourses' (46–47). By connecting knowledge and subjectivity in children's social milieu, children's understandings and interactions with the environment could be more agency based in terms of decision-making and participation based on their environmental knowledge and skills (Reid and Nikel 2008).

This notion signals the importance of participatory and responsible knowledge which values the integrity of knowledge and action, interrelatedness of being and living and responsible participation in building sound science–environment relationships (Kim and Roth 2008). Yet, cultivating participatory and responsible knowledge is neither a simple acquisition and application of scientific knowledge nor an introduction of ecological concepts as a special topic of the environment. It is a process of reflecting on sociocultural values of scientific and technological knowledge in complex relationships with the society and the environment. It is a question of how we can become responsive and responsible action-takers in those relationships (Pedretti 2003).

Science and technology were not represented by the children as value-free and separate from social values, culture and the environment. Children experience their own desires for the future of science and technology but are also aware of possible negative consequences. In their hopes for and anxieties about the future, the role of science and technology becomes intricate and even contradictory, negotiating social demands and environmental conservation. We might question how children's utopian projections and anxious understandings are shaped as well influence their decision-making and actions in the future. Researchers such as Kollmuss and Agyeman (2002) and Zeidler et al. (2005) have stated that internal factors, such as values, beliefs, judgement systems and social interactions, influence children's decision-making and problem solving, sometimes more deeply and directly than conceptual knowing. Therefore, it might be presumed that when children value social development more than environmental sustainability and continue to govern their desires and demands based on what they value, their decision-making and actions regarding science and technology might tend to fall in line with the exigencies of material and economic growth.

Thus, a pedagogical challenge remains: how detached can science teaching be from the questions raised by the subjectivity, uncertainty and complexity of students' lifeworlds? Latour (1987) argues that knowledge in 'ready-made science' is a certain, fixed and unquestionable truth, whereas knowledge in 'science-in-the-making' is open to challenges and contestable contexts and thus stands to be more explanatory of and relevant to contemporary lifeworlds. With science-in-the-making and its embrace of subjective and creative interactions and responsibilities between science and the world, which 'world' we strive to 'make' with which 'science and technology' becomes a critical question too. Regarding science and technology as merely objective conceptual knowledge in classrooms and laboratories is insufficient for addressing this question as well as the pedagogical challenge, particularly when the horizon for both has to include educating current generations to engage the complex and contested problems of today's world, let alone tomorrow's.

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Notes

1. According to South Korean Statistics (http://kostat.go.kr), South Korea had 483 people/km^2 in 2005 (world average 48 people/km^2, developed country average 23 people/km^2, developing country average 65 people/km^2) with limited natural resources. Energy consumption has increased by 3.77% on average for five years (world average 2.85%,

OECD average 0.95%). Ninety-seven percent of energy consumed in South Korea is imported from other countries.
2. This project was initially proposed as enhancing land resources and supporting the local economy by fostering and applying scientific and technological knowledge and skills. More recently, it has led to public concern about trade-offs; e.g. which will be acceptable and which will be tolerated when the project is characterized as economic growth versus the massive ecosystem destruction of the seabed around that region.

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Appendix

Table A1. The necessity of science and technology for society and nation (total $N = 85$).

Q. Do you think science and technology is necessary for our society and nation? If so, why? If not so, why?	
Yes, (94%, $n = 80$)	because it will help us with • the development of the country; nation's economy ($n = 48$) • convenience in everyday life, including access to technological products ($n = 33$) • preparation for possibilities of wars ($n = 21$) • medical developments ($n = 14$) • better environment ($n = 5$) • food resources and products ($n = 4$)
No, (5.9%, $n = 5$)	because • we already have enough advanced science and technology today ($n = 2$) • the natural environment will get destroyed more ($n = 2$) • more would be dangerous for humanity and the future ($n = 1$)

Note: The numbers of answers in the 'yes' section are more than the total number of respondents because some students answered with more than one idea.

Table A2. Science, technology and the environment (total $N = 86$).

Q. How is the development of science and technology related to the natural environment?	
It causes negative results (87.2%, $n = 75$)	such as • car and gas pollution ($n = 70$) • industrial garbage and sewage ($n = 63$) • constructing buildings and roads in nature; natural habitats threatened ($n = 58$) • wars and bio/chemical weapons and so on ($n = 8$) • noise ($n = 5$)
It does not cause negative results (12.8%, $n = 11$)	because • it is human's responsibility ($n = 9$) • of home sewage and garbage disposal ($n = 7$) • science and technology will help to solve environmental problems ($n = 6$)

Note: The numbers of answers are more than the total number of respondents because some students answered more than one idea.