Envisioning Technological Literacy in Science Education: Building Sustainable Human-Technology-Lifeworld Relationships

MIJUNG KIM
National Institute of Education
Nanyang Technological University, Singapore

WOLFF-MICHAEL ROTH
University of Victoria

ABSTRACT: Present discourses on technology education are taking a positive and value-neutral approach with utilitarian and vocational overtones. The discourses generally lack discussions of human agency and human responsibility for techno-scientific activities and technological literacy. To support the emergence of a collective civic literacy, we argue in this text that technology education needs to take up critical and value-acknowledging aspects with emphasis on building sustainable relationships among human beings, technology, and lifeworld. To understand the relationship between human agency and modern technology, we examine the nature of technology in the dimensions of technology as causality and technology as a relationship of lifeworld. Discussing Martin Heidegger's perspectives on the causalities of technology, we question how the nature of technology situates human beings in power-related relationships to the world. Understanding technology as process and relationship of lifeworld, the paper extends its discussion of the responsibility of a dialectical human-technology-lifeworld relation based on a socio-technical and ethico-moral framework of technology. By recognizing human responsibility of and for modern technology, we outline a critical and reflective approach to technological literacy. The approach challenges the position of current approaches to technology in the attempt to provide a foundation for a contemporary pedagogy of technological awareness and values.

RESUME: Aujourd'hui, les discours en matière d'enseignement de la technologie sont en train de prendre une orientation positive et dépourvue de jugement de valeur comportant des connotations

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utilitaristes et professionnelles. En général, les discours n'ouvrent pas assez de discussions sur l'action humaine et la responsabilité humaine dans les activités technico-scientifiques et dans l'alphabétisme technologique. Dans ce papier, afin de renforcer l'éclosion de l'alphabétisme civique collectif, nous ouvrons le débat sur le fait que l'enseignement de la technologie a besoin d'aborder des aspects critiques et de valeur reconnue avec un accent mis sur la construction durable des relations chez les êtres humains, dans la technologie et dans la vie mondiale. Dans le but de comprendre les relations entre l'action humaine et la technologie moderne, nous analysons la nature de la technologie en tant que causalité et en tant que relation de la vie mondiale. Nous discutons des perspectives de Martin Heidegger sur les causalités de la technologie. Nous posons des questions sur la manière que la nature de la technologie situe les êtres humains dans les relations basées sur le pouvoir face au monde. Nous assimilons la technologie comme processus et comme relation de la vie mondiale. L'article élargit les propos sur la responsabilité d'une relation dialectale humaine technologie/vie mondiale, fondée sur une structure de technologie sociotechnique et éthico morale. En reconnaissant la responsabilité humaine de et pour la technologie moderne, nous soulignons une démarche critique et réfléchie de l'alphabétisme technologique. La démarche remet en question la position des approches actuelles vers le chemin de la technologie afin d'apporter une base à une pédagogie contemporaine de sensibilisation et de valeurs technologiques.

The Modern Discourse of Technology

Watching the news, reading the newspapers, or studying Internet resources provides ample evidence of the fact that most discourses about technology in modernized society are overly optimistic, highlighting real and desired, even utopist possibilities while underestimating ethico-moral and humanistic aspects. The following quote from a recent conference concerning the worldwide web is but one of the innumerable examples one can provide in which technophiles rave about how this or that technology revolutionizes our lives.

> The World Wide Web has transformed society in the way we communicate, learn, trade, and govern. We are about to see a new wave of capability added to the World Wide Web that will revolutionise our lives over the next ten years. WWW2006 will be a showcase for these new capabilities. It offers a unique opportunity for industry, government, and the architects of the World Wide Web

> to meet and debate the global issues we face and help create the future applications for society, public administration, and business. (http://www2006.org/overview/)

Many readers will be familiar with such claims, especially about teaching and learning. In the 1970s, for example, those with stakes in computing technology predicted that computers would replace teachers within a decade or two; and B.F. Skinner, the inventor of the idea of teaching machines, predicted that students would learn twice as fast than when taught by a teacher. Today, despite all the hype with which each one of the many software generations (including "intelligent tutors") has been greeted, teachers are still in the classroom and are needed even more than they were 30 or 40 years ago – especially given the social and societal problems that are everyday experiences in our schools today.

We note in particular the rapid uptake of new technologies especially by younger generations – computer games, mobile phones with multiple capabilities, and a great range of other gizmos – that stands in stark contrast to the more hesitant adoption of new technologies on the part of older generations. More so, technologies are employed not only for those purposes that they originally had been designed for but provide opportunities for new cultural practices that continually emerge as users adopt whatever hits the market. The ever increasing speed with which new technologies become available demand forms of technological literacy that are suited not merely for coping with what exists but more so, with a continually changing culture and the resources it makes available for the action of its members (Roth, in press). This latter aspect in particular points us to the inherent ethico-moral issues, as the resources provide opportunities for actions the impact on human beings that we cannot yet envision. Thus, when the Internet was created, its inventors, politicians, or the legal system have not envisioned the new levels to which child pornography, stalking, surveillance, planning and preparation of terrorist acts, and other questionable practices could be taken.

With the ever-increasing tension between the existing social value systems and the speed of new technologies, society generally and (science and) technology educators particularly need a better framework of technological literacy to comprehend emerging technological languages and relationships. To respond to the escalating need for a value-based technological literacy, schools have been concerned with students' capacity to adopt and utilize emerging technologies in real rather than simulated settings. However, taking the position of a value-

neutral and utilitarian approach, technology education has emphasized in the preparation of students the development of merely skillful performers of techniques. Yet, the objective and value-free views of technological literacy does not and possibly cannot ever help students understand the controversial outcomes and by-products of modern technology such as radioactive wastes, genetically modified food, or the Internet in the intricate human-technology relationships. As the mediations of technology closely and exponentially changed human relationships to the world (e.g., videophone, video chat, and SMS changed how people relate), there exists a need for critical reflection on the current discourse of technological activities to construct a responsible and responsive technological literacy in contemporary society.

Technoscience and a Modern(ist) World

To begin thinking about how and in which direction to change technology education, we consider the question, "How do students relate to the present and future worlds?" The following narratives collected from Korean sixth-grade students (age 11–12) reflect the relationships between the world and technological engagement. Students point out the capacity of technoscientific development would enable new ways of overcoming human and environmental problems that we have encountered in today's world. In their explanations, science and technology as a unity of collaborative action with more technology-oriented capacity is an ultimate means to construct a better future. For instance, JaeYoung suggests that technological advances will help us build new habitats in space as a solution to future overpopulation and environmental destruction (Figure 1).

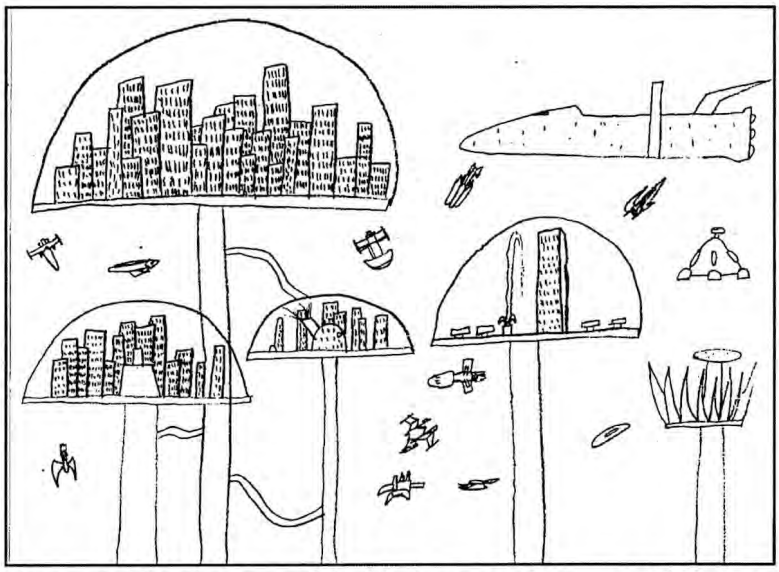

Figure 1. The drawing of JaeYoung, a twelve-year old Korean boy, produced in response to questions about a future world with science and technology.

> *I drew a city built on the sky. There would be no land left for us to live in the future because of over-populations and environmental destructions so we might need to build a city on the sky with advanced science and technology.* (Jae Young)

In JaeYoung's drawing the future lifeworlds of humans are divorced from the earth with the aid of techno-science. He has imagined flying objects, communities protected by glass domes, and high-rise buildings. Yet, he has not ignored the elements of the nature: he has drawn a place with a water fountain and benches next to the tall buildings. "*We will need this to enjoy the nature and relax,*" he explains to us while explaining his drawings. In the disconnection between the natural and technological world, we find intermingled concerns of various origins: environmental destruction, optimistic future with technological innovations, and a desire for the natural world.

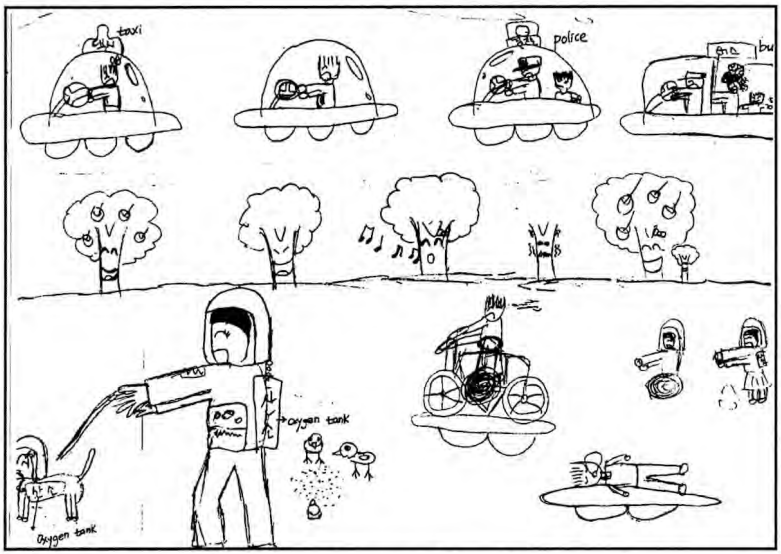

Figure 2. The drawing and text of SungWon, an eleven-year old Korean girl, produced in response to questions about a future world with science and technology.

People would need to carry oxygen tanks to breathe safely. The future environment would have more air pollution. Science and technology will help us to solve the problems. I can walk my dog by getting him an oxygen tank too. (SungWon)

In the young Korean students' narratives, technology and techno-science appear as means for coping with human concerns. Today's problems and the limitations in human capacities are overcome by techno-scientific development in the following vision SungWon has for the future (Figure 2 above).

SungWon understands that technological innovations would bring forth safe and healthy future. She smiles in her oxygen mask, feeling secure. In her optimistic view of techo-science, environmental problems do not seem to exist. The technological assistance will overcome any environmental problems in the future. In this optimistic way of thinking, the role of human beings focuses on the development of evermore-advanced techno-scientific knowledge and skills rather than a greater

degree of responsibility for the environment. The technological activity is always a reactive, not proactive response to the problems emerging with development.

This paradigm of optimism is far from bringing forth the sustainability of the future, resulting in an intrinsic contradiction in existing human-technology-lifeworld relationships.[1] For example, in students' understandings, the use of techno-science causes environmental destruction but is an inevitable byproduct for socio-economic developments.

> *There are ... huge problems like ... a landfill project on the West coast to get more land. It destroyed the ocean ecosystems around that area. ... I think science/technology and the environment have very close relationships. (Jin, age 12)*

Jin is aware of the relationships among techno-science, socio-economic development, and the ecological destructions. In her understanding, the purpose of science and technology is to develop society but this development might be destructive to the environment. Ironically, these environmental problems can be overcome by more advanced techno-science according to JaeYoung's and SungWon's perspectives. Considering these narratives, students articulated the relationship between techno-science, socio-economic development, and the environment in contradictory and unsustainable ways.

However, this perspective is not limited to these students' cases to understand the world that we live in today. A modern myth holds that human welfare can be equated with ever-increasing material well-being and this common ideology transforms decent, well-rounded citizens into single-minded consuming machines (Rees, 2002). To cater to the demands of the myth, people always strive to find ways of gaining *more* goods/services, and science and technology have become the instruments for continuous economic growth. "Many of us harbor the same double standard: we enjoy the benefits of technology while remaining largely ignorant of its inner workings. We have a society where ... we have the outward acceptance of modernity without the inner conviction" (Mayor, 1999, p. 151). For many, the marriage of material goods and technologies has become an indicator of social development. On this ideological basis, it is easy to slip into the binary understandings between the development/progress of human welfare and the exploitation of nature.

> Our technological ambition must begin to scale itself down, allowing itself to be oriented by the distinct needs of specific bioregions. Sooner or later, that is, technological civilization must accept the invitation of gravity and settle back into the land, its

> political and economic structures diversifying into the varied contours and rhythms of a more-than-human earth. (Abram, 1996, p. 272)

With these contradictory ideas of science/technology, the environment, and modern civilization, we need to reexamine the discourse of techno-science, which has been divorced from values, ethics, and solidarity for a sustainable world in modern time. If there is no recognition of the coexistence in human-environment relationships, techno-science increasingly is employed as a means for exploitation, destruction, and subjugation of large parts of society. The destruction of the environment means the destruction of human beings. There is need for our awareness, stewardship, and responsible action.

The widely accepted, optimistic notion of a modern technological world raises pedagogical concerns of critical and responsible actions in a future society where technology will be more dominant and actively engaged in human relationships. Students have been and will be engaged in technological activities more closely and dynamically, however, the pragmatic focus of school science and technology curricula does not reflect students' lived experiences nor does it encourage students to understand their roles in the relationships of techno-scientific activities and their worlds. Introducing technology as neutral and value-free, technology curricula have emphasized the ways of either testing scientific theories or promoting technological competency for vocational purposes. In this circumstance, technology becomes a necessary requirement to improve individual competency and social success. But the concerns about environmental destructions are inherent in human relationships with technology.

We argue, in contrast that what society really needs is a reconciliation of the contradictory relationships between techno-science and the environment to be able to found a way of teaching technology in science curriculum that enables the emergence of citizens with the competencies to take care of the planet that we inhabit. To examine how technological literacy embraces unfolding activities of technology in our daily lives and builds up co-constructive relationships among humans, technology, and the natural world, we begin by questioning the nature of technology in the dimensions of causality and responsibility in human lifeworld.

Understanding Modern Technology

In science education, the term *technology* has been regarded as applied science consisting of design, skills, technique, tools, and technical

innovations (McGinn, 1991). Yet, given that technologies such as brewing, construction, and metallurgy were present in human history long before the arrival of anything that might plausibly be called modern science, technology neither is mere applied science nor a discipline subordinate to science. In modern society where science and technology are intermingled in complex ways, the presence of technology is not a simple dimension of science at all (Franklin, 1992). To some extent, science is applied technology in the sense that it is impossible to project and carry out many scientific developments without technological bases and supports. Science sometimes depends on technology more than technology does on science (Sismondo, 2004). Technological practice has its own traditions and socialization; thus, "work on the history of aircraft suggests that aeronautical engineering is relatively divorced from science: engineers consult scientific results when they see a need to, but there is no sense in which their work is driven by science or in which it is the application of science" (p. 76). This quote highlights the dialectic tension between conceptions of "science as base or knowledge" and "technology as practice or production." From this perspective, technology can be taken not as merely the application of science but as a unique form of cognition and tradition with its own interactive relations to nature and human life.

To move us further in our discussion, we use the term technology broadly to designate all those implements that mediate the relation between human beings, on the one hand, and the natural world, on the other. These means allow humans to change their life conditions rather than being merely subject to them in the way most animals are. Technology therefore includes engineering technology, computer hardware and software, and network information technology. Since these technologies co-generate today's culture of science and technology, it is not appropriate to separate technology from science or to disconnect one from another, especially because of our express purpose to articulate technological literacy in the nexus of human, technology, and lifeworld.

A Phenomenological Perspective

Technologies presuppose purposes and practices. For instance, a telescope exists for observing distant objects. The purpose and practice of telescope are already embodied before our action involved. Users utilize the functions of the tool to see what the naked eye could not. While employing the tool, users are also open to new perspectives, interpretations, and further action toward the world. The tool expands human limitations by allowing the constitution of new relationships to

the world. The tool is not simply an artifact to accomplish its optical purposes but mediates the interactive and interpretive relationships to human beings and the world. What then does technology bring forth in the human-natural world relationships?

An important position often referred to comes from a phenomenological consideration of technology (Heidegger, 1954). The nature of modern technology is based on an instrumentality that is always associated with causality, which becomes a basis of question about the relationships between modern technology and human activities. To explain human relationships in the action of technology, we may begin by considering the four causes that Aristotle was the first to articulate. These four causes are foundational to western rationality and instrumentality: (a) the material cause – matter of a thing (e.g., silver); (b) the formal cause – pattern, model, or structure (e.g., a chalice); (c) the final cause – goal, purpose, function or potential (e.g., sacrificial vessel); and (d) the efficient cause – means or agency (e.g., a silversmith). In the instrumentality of technology, the causes and actions are deeply immersed, so that to understand the nature of technology, we need to understand its causality. In this regard, technology is not a mere means such as a tool or a technique but it is a realm of causality and action.

The Greek word *techn* ( ) from which the English word technology derives has the meanings of not only the:

> Activities and skills of the craftsman [but also] the art of the mind. Techné belongs to bringing-forth, to poi sis. ... It reveals whatever does not bring itself forth and does not yet lie here before us. ... [Therefore] technology comes to presence in the realm where revealing and unconcealment take place, there al theia, truth, happens. (Heidegger, 1954, pp. 294-295)

Therefore, in the action of technology we notice a process of revealing and bringing forth truth and human action becomes present. A human agent artfully takes responsibility for the instrumentality of technology and respects his or her relationships to the world. The authorship and authenticity of the silversmith create and are created by the spirit of art, poi sis.[2] The situated nature of any action reveals the poi sis of the thing and brings forth a world in the situation at hand. Questioning causality and action of technology can lead us to explore the ways in which human agency is positioned in the relationships of technology, truth, art, nature, life, and values in the responsibility for a creative relation to the world.

In this perspective on causality, modern technology disposes human beings in the unique position of the mode of ordering and destining as a way of revealing. The tendency to challenge, control, and master

emerges from the process of bringing forth in which human beings begin to regard nature as a cornucopia of resources, forgetting or misconstruing the responsible arts of poi sis (Ihde, 1990). This framework – based on *challenging nature* and *nature as standing-reserve* – becomes the essence of modern technology. Predisposing human beings to challenge everything, technology provokes us to reveal and control the world as stored, which has been denoted by *Ge-stell* (Heidegger, 1954, p. 301), a neologism based on the German word *Gestell*, which draws on a semantic field covered by the English terms stand, rack, shelf, mount, and frame.

Ironically, *Ge-stell* ultimately puts human beings themselves into the mode of standing-reserve:

> Meanwhile, man, precisely as the one so threatened, exalts himself to the posture of lord of the earth. In this way the illusion comes to prevail that everything man encounters exists only insofar as it is his construct. This illusion gives rise in turn to one final delusion: it seems as though man everywhere and always encounters only himself. (Heidegger, 1954, p. 308)

In this mode of enframing/controlling and being enframed/controlled, danger emerges in the nexus of human, technology, and lifeworld (Kroker, 2004).

Contrast the overly positive point of view on the technological world, the articulated perspective suggests a more cautious approach for rethinking not only modern technology but even more importantly postmodern technology, including especially those technologies that are (supposedly) "revolutionizing," that is, radically (or "radically") changing our lives. With complexity and the rapid changes of technology, there have been not only practical conflicts but also psychological effects such as loss of control, anxiety of obsolescence, and fragility of humanity in human relationships with the society and culture (McGinn, 1991). In this regard, we are provoked to critically reflect on narrowly focused technological literacy. The importance of responsible paths to cope with the dangerous nature of modern technology by saving power of questioning, we need to look at students' contradictory understanding of the technological world and planetary connections. To reconcile the contradiction of technology with the sustainability of the world, there needs a more constructive and collective understanding of technology and human relationships (Roth & Barton, 2004).

Actor Networks and Socio-Technical Ensembles

To construct viable future worlds, today's society needs receptive and active ways to understand our relationships to modern technology, given that human beings' technological engagements have never been separable, from the beginning of the history (Latour, 1999). Whereas Heidegger draws our attention to the cautious approach to modern technology, Latour – drawing on and elaborating the idea of a semiotic network of human and non-human (i.e., things, technology) actors – articulates an approach that is more active and intimate to understand human-technology relationships. Accordingly, technology and science interplay in an irreducible web or *network* – from whence the popularity of the term techno-science in the recent literature of the social studies of science and technology. Interactive and constitutive relationships are created within networks composed among a variety of semiotic human and nonhuman actors that contribute to the constitution of meaning. Technology is not literally an actor, but indistinguishable from an actor concerning meaning – not unlike other situations when people attribute agency to organizations ("the university asks us ..." or "Ottawa is supporting the manufacturing industry") or technology (e.g., "the software kicked me out"). This allows us to theorize human and nonhuman actors to mutually interact, shape, and translate each other. Nonhuman actors are also considered as active agents that participate in creating the dynamics of the networks.

Technology significantly modifies social relationships, and therefore has to be taken into account in attempts to understand both form and content of human relations. For example, capital is a nonhuman actor but its agency actively creates various new situations in the human relationships in a society. Its system stays strong, firm, and even self-regulating. It hardly falls away from the whole, collective network of society:

> Those who have tried to distinguish these two sorts of collective [human/nonhuman] by attributing "objectivity" and "efficiency" to modern technology and "humanity" to low-tech *poiesis* have been deeply mistaken. Objects and subjects are made simultaneously, and an increased number of subjects is directly related to the number of objects stirred – brewed – into the collective. The adjective modern does not describe an *increased distance* between society and technology or their alienation, but a deepened *intimacy*, a more intricate mesh, between the two. (Latour, 1999, p. 196)

When we enter into the complex transactions and mediations of the collective, there is no distinctive separation between humans and

nonhumans – just consider the mountain climber who scaled Mt. Everest on artificial limbs. This is the point at which we break the difficulties within a modernist position. In fact, some claim that we never have been truly modern, living in a world of opposing poles, human and nonhuman, society and nature, and society and technology (Latour, 1993). Although humans and nonhumans are separated physically, we are asked not to separate the natural world and technology (the constructed world). The actor network approach highlights *inter*-actions and co-relationships between actors and networks or humans and their environments. In actor networks, techno-scientific activity is a process of a socio-technical network where human agency and science/technology are mutually facilitated, integrated, and shaped in the space of *co-existence* and *co-emergence*. Without understanding these interrelationships, we create separation and perpetuate the illusion of an iconic realm of technology and techno-sciences and further disconnect ourselves from human-technology-lifeworld relations.

Dynamic Perspectives on Culture and Ethico-Moral Dimensions of Technology

Actor network theory articulates things, actors, and links; both features lead to a static image of culture (i.e., due to the emphasis of noun words that denote things). Not surprisingly, actor network approaches have been critiqued for the static images they invoke and alternatives, such as fluid metaphors, have been suggested as replacement (e.g., Mol & Law, 1994). The shortcoming of the fluid metaphor lies in the fact that, from our perspective, it does not sufficiently emphasize the human beings that science and technology educators face on a day-to-day basis in their classrooms. What we need instead is a theory of culture that is both dynamic and allows us to understand, in the limit, what to do in the classroom when it comes to technology education. Such an educationally relevant theory, which is based on a dialectical relation between individual and collective, has recently been articulated (e.g., Roth & Lee, 2006).

From a dialectical perspective, individuals and collective mutually presuppose each other. This means that actions cannot be ascribed to the individual alone, but always and already constitute possibilities for the collective as a whole. The individual but realizes a possibility, which inherently is a possibility for other members of a culture as well. More so, each action has an outcome that is a resource for future actions of the same or any other individual. But resources are inherently flexible in the way they can be used and interpreted. Thus, a hammer is not only a tool

for driving nails into a board, but also as a nail drawer, a weapon (a serial killer in China was convicted of 67 murders using a hammer), an object to be thrown (e.g., hammer throw), a tool to pulverize oyster shells to produce hen feed (as done by one of the authors), and so on. The possible uses of an artifact, tool, or technology explode, as present uses spawn new future uses. The already-cited explosion of cultural possibilities that continuously emerge with and for the Internet technology is but an example. Such a phenomenon as the exponentially growing action possibilities cannot be captured with static theories of culture but requires a dialectical approach.

Because new possibilities for action continuously evolve, there are particular requirements on ethics. This is so because each act only occurs once; but because an action has an effect on other people and the natural world, the person acting is responsible for everything that person does (Bakhtin, 1993; Ricœur, 1992). The quandary emerging from this lies in the fact that tomorrow's possibilities cannot be anticipated so that today's actions may lead to future possibilities with detrimental possibilities. Most scientists producing the first atomic bomb have attempted to shed their responsibilities, claiming instead that politicians used what they had produced. But from the approach articulated here, it is precisely the actions of the Los Alamos scientists that enabled the horror of Hiroshima.

Actions are completed in, by, and through the effects a performance has on others. In the past scientists, for example, constructed the atomic bomb and claimed that the moral responsibility for its uses lie with society generally and politicians particularly. But, from the ethico-moral philosophies that Paul Ricœur and Mikhail Bakthin have articulated, the person performing an act is responsible for the effect this performance has. As we point out, the outcomes of actions are resources for future actions, so that scientists not only are responsible for their performance but also for the outcomes of these performances, which means, for example, for the ways in which the atomic bomb is being used. We do not suggest that these scientists solely are responsible but rather that they are co-responsible; they have to own up to rather than divest themselves from this collective responsibility. Scientists therefore cannot abrogate their responsibilities when they genetically engineer plants that turn out to irrevocably modify the environment nor can scientists abrogate their responsibility when drugs that they develop catastrophically influence the lives of people, such as has happened with dichloro-diphenyl-trichloroethane (DDT), which has damaged wildlife and human health, agent orange, or thalidomide, which caused birth

defects in thousands of children around the world. What we envision instead are scientists who are conscious not only of the possible impacts that the products of their work have on people but also of the unforeseen and unforeseeable effects the future might turn up. These scientists are conscious of collective nature of responsibility and do not abrogate their contribution to the collective responsibility.

The public also shares the responsibility of socio-technical activities of technology through their actions. With precautious and proactive decision making on technologies for example, genetically modified food, everyday house products with environmental awareness, or the network usage, the public actively participate in building an ethico-moral relationship of technology and the world. When a new technology is introduced, it is also up to the public to enact its responsibility for critically assessing and using the technology. Without this balance-and-check participation by the public, the culture of ethico-moral relationships of technology cannot be possible. However, this act of balance-and-check or responsible performance in the public and science labs could be undervalued when the modern(ist) perspectives on society and culture continuously support the optimistic and value-free perspectives on knowledge and practice of science and technology. The responsibility of techno-scientific activities is conveniently eclipsed for the concerns of socio-economic and technological development.

We do not argue to abandon technological development, but rather we argue for a position in which scientists specifically and society generally confronts the unpredictable uses of any technology in a continuously evolving and unfolding culture. That is, we argue for a cautionary approach to technology, which inherently is associated with a position that takes into account the inherently ethico-moral dimensions of human nature.

Implications for Science Education

With the examples of dreadful consequences of techno-sciences, we question technological literacy in terms of collective responsibility of knowledge and action. The modern discourses about technology and technological literacy have constructed human-technology-world relationship on the basis of objective and value-neutral views without critical reflection on the concerns of responsible, ecological relationships among technological activities (Ihde, 1990). With much expectation for possibilities in life efficiency and social development, the discourse of modern technology emphasizes the positive and the utilitarian. Being associated with industrial and capital values, (bio-, gene-, agro-, etc.)

technology has become a crucial instrument for escalating socio-economic developments. Yet, the degree of socio-economic development does not necessarily mean the development of sustainable human-world relationships through technological mediations.

With the Korean students' narratives presented in the beginning of this text, we question about technological literacy in terms of the relationship among human being, technology, and the lifeworld in modern society where industrialization is seen as principal development. In their understandings, the relationships of technology, socio-economic development, and natural lifeworld are contradictory. Students expect the development of technology to bring us a better world. Living in a technological world, they still exhibit desire for an unscathed natural environment. This conflicting idea which mirrors the culture of a modern technological world needs to be questioned with pedagogical manners to teach technology in science education.

Throughout this paper we question the value-neutral or positive orientation of teaching technology in science education by investigating the contradictory relationships that human beings have with technology. As science educators, we see our main task to lie in the education of students to become considerate thinkers that build accountable, ethico-morally sound relationships with modern technology and the natural world of which they – because of the material nature of their bodies – are an integral and constitutive part. To do so, technology education needs to shift its approach from technology as techniques or vocational capacity to technology as action with values and responsibility. To understand the spectrum of technology and the world science education has to foster not just realizations of a planet Earth becoming an inhospitable place, in which simple everyday aspects of life such as breathing no longer are possible without even further technologies to filter and purify the air that is its most essential component. Rather, we need forms of science education that allow students to develop the competencies in which they are conscious of the ethico-moral dimensions of all their actions in the relationships between techno-scientific activities and lifeworld. It is to examine the causality of technology, that is, the consequences of their actions through utilizing technology in this world. This would then set up a situation in which not only scientists but also citizens in general act in ethico-morally defensible ways and thereby allow us to envision more positive futures than the ones some of the children featured in the introduction had envisioned.

Teaching concepts and theories as if they existed in themselves rather than in complex relations is inappropriate. Furthermore,

reproducing laboratory tasks does not introduce students into the ethico-moral dimensions of techno-science. Rather, engagement with everyday issues that threaten the natural world including human beings and the ethico-moral principle of stewardship is required.

Ethico-Morally Oriented Technology Education in the Science Curriculum

To think about the possibility of cultivating the ethico-moral principle of stewardship in collective responsible relationships of technology and lifeworld in science education, we introduce the example of a science curriculum for seventh-grade students in Central Saanich in British Columbia, Canada, that we have taught repeatedly in recent years. In Central Saanich, partially located in the Hagan Creek watershed on the Canadian West Coast, water has been a problem for many years. This part of the West Coast has a relatively dry climate (about 850 millimeters of precipitation per year) with hot dry summers and moderately wet winters. Concomitant with the climate, recent developments have exacerbated the water problem. The biological and chemical contamination of the local well water serving part of the town rises above acceptable Canadian standards during the dry period of the year, when falling water levels raise contaminant concentrations. Some citizens have to drive five kilometers to obtain useable water at the nearest gas stations. Urbanization and the related increase in impervious surfaces (pavement), losses of forest cover throughout the watershed and along the stream banks, losses of wetlands and recharge areas, the loss of natural stream conditions, and the pollutants of suburbia, lawn chemicals, and car leakage into the creek further worsen the water problem. Local industries contribute to the problems by releasing industrial wastes into the creek and its feeders.

An environmental group arose from the concerns about water quality, monitoring water quantity and quality, or contributing the rewriting of community policies. The environmentalists engaged in educational activities, which includes giving presentations throughout the community or assisting children in their Hagan Creek-related investigations. When the children hear about the sorry state of the watershed, their interests are sparked by the desire to help the community and the environmentalists. Students immediately volunteer to clean up the creek and to investigate its various facets. They design and conduct their own investigations at different parts of Hagan Creek, which they ultimately report, upon their teacher's suggestion, to the community during the annual open-house event organized by the

environmental activists. School science and village life begin to interpenetrate and, in the process, support one another. Most importantly parents, politicians, members of the local First Nations community, and others participate in making the curriculum a reality – they drive the students to various sites along the creek, they tutor and teach, or they serve as chaperones.

The idea underlying these lessons is putting students in a situation where they become active citizens who contribute to community life and collective, responsible knowledge, and action of science and technology accessible to all. This way of organizing the science lesson makes it interesting for students to produce knowledge and action in the context of a community that is much larger than "classroom knowledge" characteristic of most educational practice and theory. Further, they are supported and encouraged to find possible ways to utilize technological methods to alleviate the conflicts between human and natural worlds. In their learning, technology takes a reconciling mediation, not a destructive or exploitative position toward nature. They come to use a variety of technologies – information technology, dissolved-oxygen meters, scientific laboratories – for the purpose of constructing knowledge about the changing nature of the watershed and its health.

In this example, the seventh-grade students participate in a collective practice, taking care of and generating knowledge about a creek and its associated watershed. What the students do makes sense not only because they choose what to do and how to go about it but more importantly because they engage in a collective, ethico-morally responsible stewardship of the world they inhabit, a world changed by this inhabitation. The students enact their part of a collective motive of community, science, technology, and lifeworld. Participating in a collective praxis, they experienced ethico-moral relationships of science and technology in their action.

In the case of Central Saanich, collective ethico-moral technological literacy emerged because the citizens were involved in an issue where there was something at stake. It has been suggested that technological literacy as practical activity in the face of problems arising from everyday life include a number of competencies (Fourez, 1997). These include how to integrate communities; how to use standardized knowledge; how to translate, negotiate, and transfer knowledge; how to use everyday life knowledge to make ethical and political decisions; and how to contrast the understanding of technology with understanding of its scientific principle. In the present case, these aspects of technological literacy emerge as aspects of irreducibly collective praxis of lifeworld

relationships rather than individual prowess. There is no inherent need for all students to be competent in all of these, like there is no need for all people to be able to repair a lawnmower, lay carpets and ceramic tiles, or produce organic vegetables. We are knowledgeable when we understand the interconnected relationships to other human beings, scientific knowledge, technology, and the environment, to participate in the collective choreography and to know how to access necessary resources. In a collectively enacted curriculum, the contradictions between socioeconomic/technological development and the natural environment can be reconciled.

When, how, and where do we allow young people to be scientifically and technologically literate? The classical approach is to expose children and older students to the images of scientists' science and technician or engineers' technology. This science and technology is a pure subject, often taught in special physically separated rooms, unsullied by common sense, aesthetics, economics, or politics that are characteristics of everyday life. It is also a subject in which each individual, so goes the idealist rhetoric, has to appropriate and exhibit a certain basic skill. Whether students have this knowledge and skill is usually assessed by isolating them from social and material resources normally available in everyday situations. Conceptualizing technological literacy as a feature of collective praxis changes the situation. Science and technology educators now have to think about what to set up situations so that contexts (rather than individuals) exhibit technological literacy. How can we teachers possibly do this? Rather than preparing students for life in a technological world, we propose to create opportunities for participating in this world and to learn science and technology in the process of contributing to the everyday life in their community. Sample contexts are environmental activism, salmon enhancement, farming, or traditional food gathering ceremonies among aboriginal peoples. Early participation in community-relevant practices provides for continuous (legitimate peripheral) participation and a greater relevance of schooling to the everyday life of its main constituents.

Technology as a Relationship of Lifeworld

There needs more suitable framework to understand the changes and challenges that technology brings us in our everyday lives as it has been rapidly changing the forms, interactions, and relationships within our lifeworlds. In the complex relationships of technology and human lives, technology is not a mere tool. Nor is it simply applied science. Nor is it the utopist means to revolutionizing human life and the world. It is a

system of minds, action, and culture which interlocks us within the interrelationship of lifeworld. The functions and interactions of technology are inseparable from and indispensable in our daily routines. Moving beyond material and instrumental purposes and practice, technology becomes a process and system of relationships of our being and living in this lifeworld.

We aspire to a view of technology as a relationship that presupposes the responsibility and solidarity of our action. This requires our reflections on the causality, interconnectedness, and ever-unfolding stories of technology to bring forth a reconciled framework of human beings, technology, and the lifeworlds they inhabit. The reductionist separation of social, technological, and natural worlds is not appropriate for understanding the complexity of Being in a postmodern world. Today, being means being an active participant in an unfolding social-technological-natural world that can be understood only as a singular plural whole. In a singular plural, singularities constitute the plurality, but the plurality constitutes the singularities (Nancy, 2000). In a singular plural world, I am responsible for the Being of all other persons, who, in turn, each is responsible for my Being. In a singular plural world, we all are actors whose roles are already embedded in collective, the-one-for-the-other relationships that inherently come with an ethico-moral responsibility for the world as a whole. To reconcile the ever-increasing tension between new technologies and human lifeworlds, there need our critical collective meditations on how technology positions our being and action in this modern(ist) world and how human agency can bring forth sustainable relationships of human-technology-lifeworld to live in this time and place mindfully and responsibly.

NOTES

1. We understand the term lifeworld in the phenomenological sense of denoting the world as available in the perception and experience of people, thereby contrasting the world as materially and objectively given in scientific descriptions. Whether some material entity or process is salient to a person or group is an empirical matter rather than a fact that can be presupposed (Roth, 2006).
2. Heidegger, who frequently draws on Greek terms and etymologies, certainly was aware of the relationship between authenticity (Gr. ?, original authorship), authorship, and authority – these terms constitute a common semantic field: authority derives from original authorship.

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Mijung Kim is Assistant Professor of Natural Sciences and Science Education, National Institute of Education (NIE), Singapore. Before she joined the NIE, she worked as a research Assistant Professor and postdoctoral researcher at Seoul National University as well as at the University of Victoria. She has also taught in public elementary schools in Seoul, Korea before pursuing her graduate work at the University of Alberta, Canada. Her research interests are in scientific literacy, Science, Technology, Society, and the Environment (STSE) issues, and scientific inquiry.

Wolff-Michael Roth is Lansdowne Professor of Applied Cognitive Science at the University of Victoria. His main research interests are knowing and learning in mathematics and science along the entire life span, beginning with early childhood education to late adulthood. His work is interdisciplinary, drawing on theoretical frameworks from sociology, philosophy, cognitive science, cultural-historical psychology, linguistics, and anthropology. He has published nearly 300 journal articles, over 100 chapters, and nearly 30 books.

Authors' Addresses:
Mijung Kim
A/G NSSE
National Institute of Education
Nanyang Technological University
1 Nanyang Walk
SINGAPORE 637616
EMAIL: mijung.kim@nie.edu.sg

Wolff-Michael Roth
University of Victoria
MacLaurin Building A548
Victoria, BC
CANADA V8W 3N4
EMAIL: mroth@uvic.ca