Humanistic Science Education through Context-Rich Approaches*

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맥락 중심 접근법을 통한 인간주의적 과학 교육

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국문 초록

흔히 학교 교육은 학습자의 관심과 필요와 지나치게 동떨어져 있으며 인간 중심적 접근보다는 과학자 중심의 접근법을 유지하고 있다는 비판을 받고 있다. 실제로 과학이 주로 교실 안에서 교과서에 기초하여 가르쳐지지만, 과학의 학습이 교육과정과 학교의 울타리에 국한될 수는 없다. 먼저, 이 논문은 일련의 비유를 통해 과학 교육의 역사적 발전 과정을 간략히 요약·특징화하고, 이어서 과학 교육의 인간주의적 측면과 상황의 차원을 강조하는 소위 'Hearts-On' 과학교육의 새로운 비유를 제안한다. 둘째로, 본 논문은 내용의 상황(즉, 물리적, 개인적, 사회적, 전 지구적)과 학습의 상황(즉, 교과서적, 실험실적, 교실적, 지역사회적, 전 지구적)의 측면에서 전통적인 학교 과학(특히, 물리)교육이 얼마나 제한되어 있는가를 비판적으로 점검한다. 셋째로, 저자 및 동료들이 최근 수행하고 있는 시도들을 Hearts-On 과학교육의 예로 소개한다. 특히, 일련의 지역 사회-기반 과학 프로그램과 상황 물리 책자(즉, 몸물리, 걸치는 물리, 식탁 물리, 스포츠 물리)의 개발 과정들을 요약한다. 마지막으로, 과학적 인간주의라는 아이디어가 과학 교육의 상황중심적 접근법과 관련하여 논의된다. 이 논문이 과학 교육을 어떻게 교육과정과 학교라는 울타리를 넘는 보다 인간주의적인 것으로 확장할 수 있는가의 문제를 고민하는 데 도움이 되었으면 한다.

주요어 : 상황, 물리 교육, 과학의 인간화, 지역 사회, 과학적 인간주의

I. INTRODUCTION

The science curricula we need are those that will help close the gaps between science and human affairs. Such programs should emphasize the utilization of science knowledge to extend human capacities as a social as well as a biological species. This means a focus on the operational use of the findings of science to enhance human adaptation. By contrast, the traditional view is that a science course should stress the structure of a discipline from an academic and a career viewpoint, a view that sees a school science as preparation for college rather than preparation for life. (P. D. Hurd, 1997, p.79)

Recently in Korea, like in many other developed countries, there has been a serious socio-cultural phenomenon of avoiding the study of science and engineering among secondary and tertiary students. During the fast expanding period of Korean economy, 1960s to mid 1990s, science and engineering were considered as the areas of prosperity and the most talented stu-

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dents were willingly joined the stream. Since the economic crisis in 1997, the condition of the job market in Korea has been considerably shrunk and the finding a secure job in science and engineering became much tougher too. Once this relative prosperity disappeared, science (and technology) in school quickly had to confront with the overwhelming reluctance of students to the study of science. Students, particularly in secondary schools, were quick to realize that studying science hardly satisfy either their future jobs or their present curiosity. School science is still being considered to be too remote from their interest and needs (KSF, 2004).

On the other hand, ordinary citizens of modern society live in an age of science and technology (S&T). Continuing advances in S&T had a pervasive impact on both the ways of producing and consuming of wealth. Citizens are now no longer the outsiders or mere receivers of science. Modern society needs the active participation of citizen and their 'citizen science', which assists the need and concerns of citizens and comprises their contextual knowledge (Irwin, 1995). Scientific literacy became essential part not only of general education but also of citizen science (Popli, 1999; Laugksch, 1999). Furthermore, as the influence of S&T on society increases rapidly, various science-related social issues became serious topics which often divide the society apart. Stem cell research and the ethics of scientific research would be just a few examples of it.

Today, science education is facing the double challenges from the both sides, one from the students who are losing their interest and the other from the society which demands much broader and more active interaction from science. If school science can not properly respond to these challenges, it would be easily neglected both by the students and by the society.

The traditional scientist-oriented, often called 'the pipeline', approach is frequently accused as one of the main causes of the situation. "The traditional science curriculum advocates canonical science content and the habits of mind (i.e. thinking and believing like a scientist). ··· Most high school students embrace career goals outside the pipeline and often do not feel comfortable in its scientist-oriented ideology. These students experience school science as a foreign culture. They would prefer a science education for everyday life." z(Aikenhead, 2006, p.1). We need alternative rationales, perhaps humanistic perspectives as called by Aikenhead(2006), for science education which sees science as a human endeavor and science education as enculturation into science, embedded within a social milieu of 'modern' society, through which we can meet the double challenges.

With this background, this paper first overviews the historical changes of science education paradigms and suggests a new paradigm, called Hearts-On science education, which is supposed to have humanistic perspectives (i.e. scientific humanism). Secondly, this paper discusses critically the current situation of school (particularly physics) science, particularly from the perspectives of the context which is considered to be the main focus of teaching in Hearts-On science education. Then two alternative examples of the context-rich approach recently conducted by the author and colleagues (i.e. a series of community-based science program and a series of science book development) are given with some explanations of their backgrounds and features. Finally, the paper discusses the relationship between the context-rich approach with the idea of scientific humanism.

II. THE PARADIGM CHANGES IN THE HISTORY OF SCIENCE EDUCATION

Although science is now considered as one of the core subjects of school across the world, science was first introduced into schools as a rather late comer after the beginning of the 19th century. Before the introduction of science into schools, it used to be taught largely in universities either as a part of mathematics or of natural philosophy mostly from the perspectives of philosophy, especially of deduction. Reading classics, such as of Aristotle, Galilei, Descartes, Bacon and Newton, was the main means of teaching science usually without experimental work or practical knowledge, with some exceptions like Comenius and sense realism

(Turner, 1927).

Despite some degree of the shift toward a more elite-oriented subject around the turn of the century by a few legendary figures of early science education (e. g. T. H. Huxley and H. E. Armstrong) (DeBoer, 1991; Jenkins, 1979), under the influence of Industrial Revolution in England and Europe, school science during the 19th century was largely taught as a body of practical knowledge supposed to be useful for individuals' profession as well as for countries' competitive power (Song, 1999). The typical examples of this tendency would be the Mechanics' Institution movement during the first half of the 19th century (Cardwell, 1972). The tendency toward practical knowledge continued throughout the first half of the 20th century, but this time with more emphasis on individuals' life and science in society. While in Britain there was 'Citizen Science' movement during 1930s～40s led by a group of socialist scientist group (esp. L. Hogben & J. D. Bernal) (Song, 2001; Werskey, 1978), in the US there was a movement of progressive education and of everyday life science with more capitalistic flavor during 1920s～50s (DeBoer, 1991).

Toward the end of 1950s there was an accumulating pressure largely from the community of scientists for a radical reform of school science at the both sides of the Atlantic. The movement, often called Curriculum Reform Movement represented by PSSC and CHEM Study in the US and Nuffield sciences in the UK, emphasized scientific inquiry rather than the body of scientific knowledge (e.g. Schwab, 1962; Matthews, 1994). This was largely based on the positivist philosophy of science of which the focal interest was the experimental method (in other words, discovery) of science. Students were usually asked to have authentic experience of discovery and the understanding of the conceptual structure of science. Due to the emphasis on the inquiry activity, science education during this period is often identified with a phrase of 'Hands-On'.

During the 1980s～90s, with a philosophical background of constructivism largely initiated by J. Piaget and D. Ausubel, there were a huge shift toward the studying of scientific conceptions of students across the world (e.g. Black & Lucas, 1993; Driver *et al.*, 1994). Throughout the period, however, the main locus of the research had been gradually shifted from identifying students' misconceptions to investigating the nature of conceptual understanding and developing effective strategies of conceptual changes. The focus of the studies was to make students experience their own cognitive conflict which is considered as an important precondition for successful conceptual change, and students were expected to construct their own conceptual framework through the interaction with peer students and teachers. Since the movement emphasized students' conceptual understanding rather than their activity, it is often referred as 'Minds-On' movement.

Toward the turn of the century cultural approaches gradually gained the attention of science educators. Science is no longer seen just as a discipline or discovery method or even personal construct but often as a socially constructed culture (e.g. Weinstein, 1998). Socio-cultural interactions between students and between a student and a teacher became of main interest of science education researchers who were often in support of the theory of situated cognition (Aikenhead, 1996; Lave & Wenger, 1991). Within this framework, the contexts of science and of science learning were the focal points of consideration. The communicative nature of science learning, inside and outside of classroom, needs to be investigated in-depth, for example in terms of argumentation inside the classroom and in terms of informal / free-choice science education outside the classroom (Falk, 2001). Although not yet widely accepted, the background philosophy of this movement can be named as 'Humanistic' (Donnelly, 2004; Aikenhead, 2006) or of 'Scientific Humanism' (Song & Cho, 2004).

Song & Cho (2004), based on their brief sketch of the historical development of science education and science museums & centers, characterized the overall pattern of the historical development of science education as the change of paradigms with corresponding analogies referring to the parts of human body (See Table 1.): Ears-On → Eyes-On → Hands-On → Minds-On → Hearts-On.

Table 1. The Change of the Paradigms of Science Education

Aspect \ Period	Until 18C	19C~Mid 20C	1960s~70s	1980s~90s	21C
Period of Science as	Natural Philosophy	School Subject(s)	Discovery Method	Personal Construct	Culture
Background Philosophy	Deduction	Empiricism	Positivism	Constructivism	Scientific Humanism
Essence of Science Learning	Logic & Reasoning	Knowledge & Utility	Discovery Process & Conceptual Structure	Prior Experience & Conceptual Change	Situated Understanding & Participation
Focus of Science Teaching	Philosophical Argument	Demonstration of Usefulness	Scientific Inquiry	Cognitive Conflict	Context of Science & Learning
Corresponding Analogy	Ears-On	Eyes-On	Hands-On	Minds-On	Hearts-On

III. CONTEXT AND SCHOOL SCIENCE

As shown in Table 1, in the paradigm of 'Hearts-On' science education, the context dimension is the focus of science teaching and, at the same time, is the accompanying condition for 'science as culture', scientific humanism, and situated understanding & participation. The context is the key of the relevance of science curriculum, which is valued most by the humanistic approaches and would ultimately contribute to 'learned curriculum' not just to 'intended curriculum' or 'taught curriculum' (Cambell & Lubben, 2000; Aikenhead, 2006).

Recently the dimension of context has gathered a considerable attention from science educators. There have been a number of attempts to classify the dimension of context into its sub-categories and to understand the process of learning (e.g. Song, 1997). In particular, some models which tried to link learning with its context dimensions have been proposed. For example, Falk & Dierking(2000) developed the 'Contextual Model of Learning' consisting of three inter-wining contexts (i.e. personal, socio-cultural and physical contexts), which was suggested for the basic platform for describing learning from museums. For a more sophisticated description of the learning experience in science centers, Hong & Song(2005) developed the CoDiLE (Context Diagram of Learning Experience) in which the links and their patterns between nine contextual factors are investigated.

However, most studies on the context dimension have tried to classify the context dimension further into its components, with an implicit assumption that the classification of the context would be one dimensional. The activity of teaching and learning, not only in science education but in education in general, is in fact the combination of two basic components, that is, the content to be taught and the activity of learning (or teaching). For example, when the principle of energy conservation is taught with the help of a textbook, the principle of energy conservation would be the content to be taught while the textbook would be the means of learning activity. It is thus necessary to consider the issue of context in terms of these two components. In other words, the dimension of context would have two components, i.e. the context of content and the context of learning.

The context of (physics) content can be further classified into its four components (i.e. physical, personal, social and global). While most laws, principles and phenomena of physics (such as, laws of motion, energy conservation, thermal expansion and so on) belong to the physical context, a lot of the facts, information, phenomena and applications of physics can belong to other components. For example, personal health - related facts and information which are to be explained with physics are of the personal component, many of STS-related issues (like traffic, industry, recycling, electricity and other everyday topics) are of the social, and the phenomena of a larger scale (like global warming, green house effect, air pollution, nuclear issue) are of the global contexts. It is true that we have, maybe implicitly or as a habit of mind, assumed that physics is only to do with general principles and laws (i.e. here the physical context of the content) and the rest would be mere the applications of physics to personal, social and global issues. It is however a strong belief of the author that the facts, data, instances and phenomena which are to be explained by physics are also the essential components of physics learning, which also need to be taught and learned in physics education. It is quite clear, from our repeated experience and studies, that what most students really want to study are the whole contexts not just the physical context of the content of physics (e.g. Choi & Song, 1996).

The context of learning (physics) can also be further divided into five components (i.e. textbook, laboratory, classroom, local and global). In many occasions physics is still taught mainly by means of textbooks and the textbooks are indeed the main platform of physics education in every country, advanced or not. The laboratory activity would be the second most common means of physics education, through which the inquiry, the most important goal of science education, is mainly practised. The third context of learning is classroom where students are engaged in group discussion, presentation, project work and so on. In most cases school physics is usually confined into these three contexts of learning. However, physics can also be educated through local activities (e.g. doing survey or gathering data in a community, participating in science fairs, visiting science centers, attending science classes in community center) and global activities (e.g. video conference with students in other countries, data logging for global environmental issues, participating in international competitions and events, student exchange programs). To the extent that school education aims to foster students as citizens with, global as well as local, scientific literacy and to make them see science from a wider perspective, school science needs to focus more on the last two contexts of learning science.

Table 2 shows the author's personal judgement on the situation of school physics education in terms of the two dimensions of the context. The number of stars in the cells of the table represents the relative frequency of school physics which belongs to the particular combination of the two dimensions of contexts. This is, of cause, just for illustrating how much the current situation (particularly in Korea) is biased in favor of the physical and personal contexts of content and of the textbook and laboratory contexts of learning. Although the case of physics education is given above as example, the situation and condition would not be different across science subjects, including elementary school science. If we want to have more student-friendly and scientific literacy- oriented physics or science, not only everyday life stuff with traditional science but also modern life stuff with modern science and technology, it is important to pay much more attention to the personal, social and global contexts of content and to classroom, local, and global contexts of learning.

Table 2. The Contexts of Content and of Learning in School Physics

Context of Content / Context of Learning	Physical	Personal	Social	Global
Textbook	*****	***	***	**
Laboratory	****	***	**	*
Classroom	***	**	**	*
Local	**	*	**	*
Global	*	*	*	*

The * represents the relative frequency, from 'almost none'(*) to most frequently(*****).

IV. SNU COMMUNITY-BASED SCIENCE PROGRAMS

For the last four years or so, a team of science educators at SNU (Seoul National University), Korea has carried out a series of community-based science programs for its local area, with a special attention to ordinary housewives. Table 3 outlines the three projects which were carried out from 2002 to 2005. As

Table 3. Summary of the SNU Community-Based Science Programs (2002~2005)

Projects	1st Project	2nd Project	3rd Project
Period	Feb.~Nov. 2002	Oct. 2004~Mar. 2005	Feb.~July 2005
Titles	*A development of the programs for improving housewives' understanding of ST in Korea*	*Development of programs and activity manual for regional science class*	*Kwnak-Gu science classes for housewives*
Participants	2 professors 2 PG students	2 professors 4 PG students	2 professors 8 PG students 6 local groups
Funding	KSF	KSF	KSF
Budget	about 10,000 USD	about 30,000 USD	about 30,000 USD
Main Activities	-Survey of Housewives -Sample materials	-Activity Manuals -Group work program -Career program	(for each group) -10 lessons -2 public lectures
Nature	A research project with a development of sample materials	A development of programs and activity manuals	A community-based science program

citizens, housewives play important roles in society as well as in home, and that was the reason for us to pay particular attention to the group. They take care of family health, purchase household goods, and help their children's study. Along with these roles of managers, consumers, and educators, they also have responsibility as citizens in democratic society to make personal decisions and sometimes voluntary participation in relation to S&T-related controversial issues. For these roles, housewives are expected to be scientifically literate and to be provided with various opportunities for improving their scientific literacy. However they have been the subjects of only a few studies (e.g. Kim *et al.*, 2004). In the following some outlines of the projects during the period are presented.

(1st Project) Basic Survey and Developing Sample Materials

In 2002, a team of science education specialists from Seoul National University (SNU) undertook a project, titled 'A Development of the Programs for Improving Housewives' Understanding of Science and Technology in Korea', with a grant from Korea Science Foundation (KSF). The research team carriedout a survey to find out their attitudes toward S&T, interests about S&T-related issues, school science experience, preferred formats of science culture programs, etc. Based on the results of the survey, a program and a set of samples of educational materials for housewives' understanding of S&T were developed.

The SNU team consisted of two sub-groups, physics and biology, each of which consisted of one professor and one postgraduate. This small scale research project was offered as one of the projects in 2002 Funding Scheme of the KSF. The duration of the project was just 10 months Feb.~Nov., 2002, and its theme was given by the KSF.

Based on the survey results (Kim *et al.*, 2004), the researchers recommended the implementing methods of the program in the following order: firstly, TV program secondly, Internet service thirdly, books fourthly, the programs of cultural/local centers. However, it turned out to implement the programs through the forth way, because MOST(the Ministry of Science and Technology) suddenly launched a national project called 'Science Korea' which included 'Classes for Science and Life' Project to be implemented through local town offices across the country. The 'Science Korea' project is a government-driven project for establishing a nationwide infrastructure for enhancing science culture. In June, 2005, under the umbrella of 'Science Korea' project, there were 19 Science Culture Cities, 350

Classes for Science and Life, 2,427 Youth Science Clubs, and 1,042 Science Ambassadors.

(2nd Project) Developing Activity Manuals

In 2004, a group with the same team leaders carried out the next project, titled "A Development of Programs and Activity Manual for Regional Science Classes", which included the development of programs (1) for people's recognition of the importance of S&T, (2) for the students' positive attitude toward S&T career pursuit, and (3) the development of Activity Manuals specially for community-based science lessons for local housewives as a part of 'Classes for Science & Life' Project. For the third, two kinds of Activity Manuals (one for instructors and one for housewives) were developed with 10 topics.

The SNU team again consisted of two sub-groups, physics and biology, each of which consisted of one professor and two postgraduate students. This project was suggested by the KSF to SNU team because after the launching 'Classes for Science & Life' Project the KSF needed to have some programs and materials to be distributed to local town offices across the country. Since everything had been decided so quickly, the duration of the project was given just 6 months, Oct. 2004～March 2005.

(3rd Project) Implementing the Programs and Manuals

In 2005, the SNU team started to implement their programs and materials to the groups of housewives in local community, Kwanak-Gu ward in Seoul, where the university is located. Kwanak-Gu is largely considered as an area of relatively low socioeconomic status and educational prospects. At the beginning stage, six groups (i.e. six local town offices) of full- time housewives with a maximum of 20 in each group were formed with a help from the local government. The program lasted 6 months (Feb.～July, 2005), and each group was given 10 two-hour's classes (of a mixture of practical work, discussion and lecture) once a fortnight in addition to two times of public lecture. This was a corporative science program for local citizens of Kwanak-Gu, developed and implemented by a SNU team, with an administrative support from Kwanak-Gu local government and with a financial support from the central government through the KSF.

For this first round of implementation, the SNU team with the same team leaders as the previous two projects consisted of two sub-groups, physics and biology, each of which consisted of one professor and four postgraduate students. Although the planning and preparation of the classes were done as a work of the whole SNU team, the actual classes are mostly delivered by the postgraduate students. The fund from the KSF was assigned according to the number of participating local town offices to the program. For the evaluation of the first implementation process, a small scale survey and interviews with three participating groups (Kwanak-Gu, SNU, and KSF) and with course attendees (i.e. local housewives) were carried out throughout this implementation process.

After the evaluation of the first round, the second round of the implementation was carried out starting from on July 25, 2005 for another eight months. This time the program was delivered to the students of grade 4 to 6 of elementary schools and their mothers. Due to the change of the attendees from housewives to elementary students and mothers, the contents of the biology team had to be changed into more inquiry-oriented topics not necessarily directly related to housewives' interest and concerns. The results, especially the turnout rate of the attendees which had gradually decreased with the housewife-only groups of an earlier trail, showed a great success. The presence of their children made them to concentrate on the programs and there were active interactions between mothers and children.

In summary, the SNU group acquired a lot of practical experience of running community-based programs with which the group had no previous experience. Through the continuous communication and cooperation with other participating groups, each participating group (SNU, Kwanak-Gu, and KSF) was able to reduce to a considerable degree the gaps which had been naturally imposed by their lack of interaction in the past. Nevertheless, as shown in Fig. 1, since each participating group has their own expertise as well as weakness and is somehow controlled by corresponding central governmental organization, there are still mismatches of purposes and opinions which are to be resolved through future collaborations. The project is still continued through its fourth and fifth forms with some changes. This change of the audience made the science program much more attractive and successful.

V. DEVELOPING CONTEXT-RICH MATERIALS: CONTEXTUAL PHYSICS

In addition to community-based science programs, the EPIC(Education of Physics In Context) group of SNU is developing, as one of the context-rich approaches, so-called 'Contextual Physics' series of which expected audiences are from the higher grades of elementary school to high school students. At the moment the series consists of four books (Body Physics, Wearing Physics, Dining Table Physics, and Sports Physics) covering various aspects mainly of the personal and social contexts of physics contents. Each book is aimed to deliver distinctive messages of physics and learning physics. The mysterious & amazing, charming and convenient, healthy & useful, and powerful & exciting (supposed) features of physics and physics learning are to be delivered as the intended messages through Body Physics, Wearing Physics, Dining Table Physics and Sports Physics, respectively. These features and intended messages are hoped to convert the common negative images of physics and physics learning (that is, boring, distant, difficult, irrelevant, only for the talented etc.) into more humanistic and easy-to-access images.

Table 4 summarizes the main contents and features of the series. The sequence of the series is arranged along the outward direction starting from myself. In order words, the Body Physics is to do with the human body which concerns biological and physical features of my own body, the Wearing Physics with something put on the body, the Dining Table Physics with food and eating which is essential for our life and something inside home, and the Sports Physics with

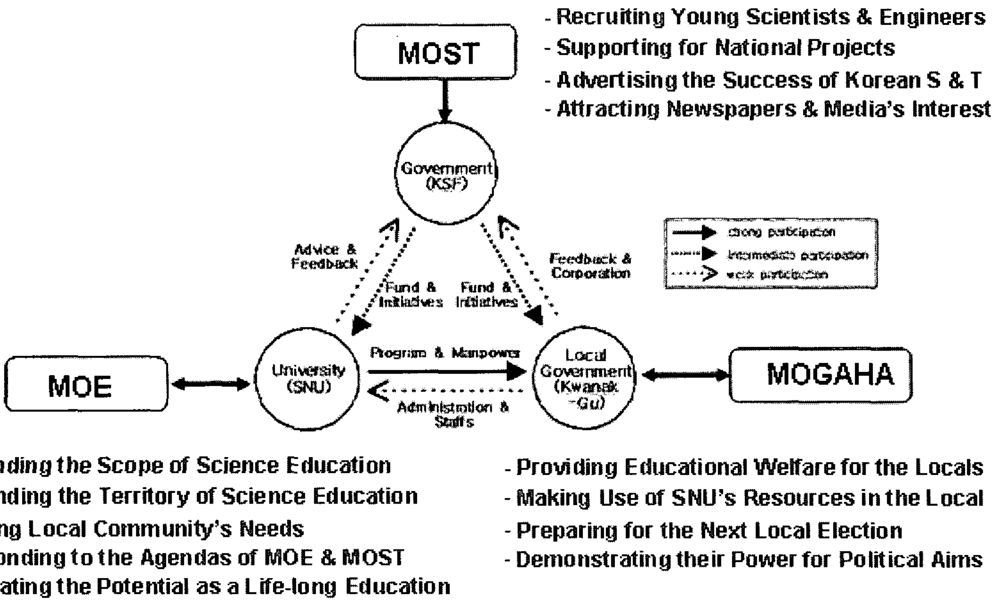

Fig. 1. The Network of Participating Groups for SNU Community-Based Science Programs with Their Declared and Hidden Purposes (MOE: Ministry of Education & Human Resources Development, MOST: Ministry of Science & Technology, MOGAHA: Ministry of Government Administration and Home Affairs).

the activities which can be enjoyed outside home.

The books are being developed with a common structure. Each book contains about twenty topics specific to its title. Each topic starts with a diary either written by a child or teenager and is of the length of about 6~10 pages. The diary describes an interesting happening of the day and is followed by the main text which progresses in a form of dialogue along the storyline following the happening described in the diary. The dialogue is set between a famous scientist (such as, Newton) and his young and somewhat naughty(of similar age with the expected audience) assistant (such as, Mr. U-turn). The names of the assistants of the scientists are matched in pronunciation with their masters but with rather amusing meanings imbedded in Korean pronunciation. Through the lively dialogue between a scientist and his assistant, the main concept and contents are introduced with some detailed explanations here and there along the dialogue. Each topic also contains several special sessions, called 'Wisdom Box from History' and 'Wisdom Box for Life', and usually hands- on activities related to the topic's main concept at the end of the topic.

The first book, *Body Physics*, is dealing with the physical and biological functions and features of the parts of human body. The basic idea of this book is that the human body which has been usually considered to be the subject of biology can also be an very interesting and helpful subject for teaching & learning of physics concepts. For instance, the structure of bone and muscle provides good examples of the principle of lever (i.e. moment and torque). The topic of Breath can be used to explore the concept of isothermal expansion. Through this book, it is hoped that students realize that physics is useful to understand my own body and health and has a strong relationship with biology.

The second book, *Wearing Physics*, is dealing with things that we wear or put on our body, such as cloths, helmet, accessories. The cosmetics and suntan cream are also included as topics in this book. Some more complex devices, such as headphones are included too. The message to deliver through this book is something like, 'science/physics is charming and convenient'. Physics would help you to be more comfortable as well as looking good.

The third book, *Dining Table Physics*, is dealing with topics of food, cooking and cookery which can be found on dining tables and in the kitchen. The main message of this book is 'physics can be of healthy and useful'. This book is expected to bring physics closer especially to the housewives who are usually unfriendly with science and physics in particular. If housewives are equipped with scientific knowledge or at least familiar with scientific phenomena related to cooking and kitchen, there would be more active interactions with their children who are studying science in school.

The fourth book, *Sports Physics*, is to do with various sports activity which is most favorite among youngsters. The main message to deliver through this book is 'science is powerful and exciting'. Although science is in fact somewhat serious and abstract, it is hoped to tell the readers that science is everywhere, especially in sports, as underlying principles and as applied concepts. Most of the activities and their devices of different kinds of sports can be explained and understood on the basis of the concepts of mechanics.

Besides the books above which are under development, the EPIC group is also hoping, as a long-term target, to expand the scope of the Contextual Physics series. There are several titles being considered for future publication: for example, *Classroom Physics* (explaining physics of the things and phenomena which students can meet everyday inside the classroom, such as, white board and marker, books and pencils, window glass, fluorescent lamp, beam projector, screen, table and chairs etc.), *Street Physics* (explaining physics of the things and phenomena which you can meet in the street, such as, traffic light system, street mirrors, bus card, road signs, vending machines, escalator, mirage on the asphalt, air pollution etc.) and others (like, *Safety Physics*, *Unit Physics*).

Although we have taught physics in schools at least for the last one hundred years, we are not perfectly prepared to teach physics. Physics education specialists as well as physics teachers, although they are equipped with proper theories and knowledge, are often lack of

Table 4. The Series of Contextual Physics being developed by EPIC group

Book titles	Focused message	Examples of units included	Common features
1. Body Physics	Mysterious & amazing	Achilles' tendon (Principle of lever) Arm-wrestling (Torque) Tuning (Angular momentum) Impossible posture (enter of mass) Arthritis (Friction) Floating (Specific Gravity) High blood pressure (Pressure, bernoulli's theorem) Lung & skin (Elasticity, hook's Law) Eye (Light spectrum) Skin care (Electromagnetic wave) Vocal cords (Sound wave, vibration) Inner ear (Inertia) Breath (Isothermal expansion) Magic eye (Light reflection)	**(Series constitution)** - 4 books (or more) - about 20 Units / book **(Structure of a topic)** Diary of students + Conversation between scientist and his assistant + Introduction of physics concepts + Wisdom Boxes (History & life) + Hand-on Activity **(Characters)** Diary (Several teenagers) + Conversation btw. scientist & assistant (e.g. Newton & U-turn)
2. Wearing Physics	Charming & convenient	Suntan (Ultra violet light) Mobile phone (Electromagnetic wave) Gore-tex (Phase transition, water & vapor) Headphones (Hz, dB, wave Interference) Masks (Order of size) Backpack (Balance of forces, torque) Safety Helmet (Momentum & impulse) Hair Band (Elasticity) Spectacles (Refractive index, aberration) Diamond (Reflection, refraction) Watch (Fluorescence, phosphorescence, Energy level)	
3. Dining Table Physics	Healthy & useful	Kimchi refrigerator (change of state, latent heat) Hot pot (Conduction & convection of heat) Eggs (Laws of motion) Dish dryer (Ultra violet light, fluorescence) Cookery (Lever) Diet cock (Calorie, density) Boiling water (Boiling & sound) Spoons (Lens & reflection) Gas cooker (Piezoelectricity) Instant noodles (Air pressure) Pizza (Falling & circular motion)	
4. Sports Physics	Powerful & exciting	Bicycle (Center of mass, work & power) Badminton/tennis (Trajectory, sweet spot) Snow board (Terminal speed, circular motion) Skating (Angular momentum, friction) Soccer (Bernoulli's theorem, restitution, spin) Basketball (Spin balance of forces) Martial art (Momentum, impulse, torque) Marathon (Velocity, acceleration, action-reaction) Sports on the moon (Gravity, trajectory)	

(EPIC:Education of Physics In Context, a research group in Seoul National University)

practical knowledge on how physics is used or how to explain things around us with physics. What we teach or need to teach through physics is not only the contents of physics itself but also the contexts (in other words, the application or instances) of physics. The context, together with the content which we science educators have exclusively focused on, of physics is one of the two key components of physics education. The assumption, embedded in our traditional practice of teaching science, that the knowledge of the contexts can either be delivered automatically or learned by students themselves is now to be reconsidered critically. As White(1988) pointed out earlier, "perception of context is important in learning because it determines what the individual thinks is the purpose of the learning. ... different perceptions of context will encourage development of different cognitive strategies, and different patterns of learning will follow. (p.20)".

VI. CONCLUSION

The curriculum of science, national or local, usually contains four common goals (that is, scientific knowledge, scientific inquiry, attitude and interest, and relationship between science and society). But it is often lack of the ultimate goal of studying science, that is, for what we need to study science after all. Are we bring up future citizens who are prepared to sympathized with the condition, needs and pains of peer, local and global communities and to make effort to improve the situation with their learned science? It could be a highly value-added thing which tends to be avoided by science educators, maybe based on the common belief that science should not be value-biased.

However, it is a firm position of the author that we need to address the valued-added goals and pursue them more explicitly and that the goal of science education needs to be something to do with 'science serving for human welfare'. Particularly, in this highly technology-driven society in which human being as a whole is much dependent on science, school science must share the spirit (or philosophy) of humanism. It is thus argued that the philosophical background of science education needs to be 'scientific humanism' although it is at present difficult to define it clearly. The idea of scientific humanism needs to be readdressed much more rigorously if it would be linked with the objective and practice of science education, although similar versions of it have been 'uncommonly' brought forward by some forward-looking minds throughout the last century.

> Are we entering a new age? Will we adjust ourselves to the new world which modern science has disclosed? Is there to be a new flowering of the mind and spirit quickened by the vast extensions of knowledge and power with which we have been endowed, as the Renaissance flowered in Humanism four centuries ago? Shall our present transition time with all its unparalleled possibilities for good and for ill culminate in a great civilization or in a great catastrophe? ... Yet we may safely predict that the outcome will be largely determined by what we, of this transition epoch, think and do. ... (L. Stoddard, *Scientific Humanism*, 1926, forward)

> A (Scientific) Humanism that is also scientific sees man endowed with infinite powers of control should he care to exercise them. More importantly, in the perspective of scientific knowledge, it sees man against his true background of the irresponsible matter and energy of which he is himself composed, of the long, blind evolution of which he is himself a product. Humanity thus appears as a very peculiar phenomenon - a fraction of the universal world-stuff which, as [the] result of long processes of change and strife, has been made conscious of itself and of its relations with the rest of the world-stuff, capable of describing, feeling, judging and planning. It is the experiment of the universe in rational self-consciousness. (Julian S. Huxley, 1941 - qouted from G. Blue, 2001)

The context brings us the questions of 5W1H (i.e. who, what, when, where, why, and how) and thus does so the meaning of science learning. In order to achieve this, once again we need to pay more attention to the contexts to which we have not been attuned enough so far, as illustrated in Table 2. That is why some context-rich (including formal and informal) approaches to science education, beyond the traditional boundaries of school curriculum and school, are highly demanded these days. This context dimension would shape the relevance of science which is usually recognized differently by different groups of stakeholder (i.e. academic scientists, general public, people in science-based occupation, media, expert on real-life issues, students, and culture interpreters) of science curriculum (Aikenhead, 2006).

This paper discussed the issues of context dimension and humanistic approach in science education, but rather from the perspectives of physics education and secondary science. However, physics education and secobadry science were introduced just as typical examples of science education. It is thus true that the discussions and points made in this paper would also be more or less equally applicable to other science subjects and elementary science too. In addition, the importance of context and the need of humanistic perspectives are not also confined to informal education as seemingly stressed in this paper, but must be common to science education in general, regardless of the boundaries of curriculum and school.

VII. ABSTRACT

School science is often criticized as being too remote from both learners' interests and needs and as maintaining scientist-oriented approaches rather than humanistic ones. Although science is mainly taught on the basis of textbooks inside classrooms, the learning of science can not be confined to the boundaries of curriculum and school. Firstly, this paper briefly reviews and characterizes the historical development of science education with a series of analogies, and then suggests a new analogy, a so-called 'Hearts-On' approach to science education which emphasizes the humanistic aspects and the contextual dimension of science education. Secondly, it critically examines how much traditional school science teaching, particularly in physics, is limited in terms of the context of learning (i.e. textbook, laboratory, classroom, local, and global) as well as in terms of the context of the contents (i.e. physical, personal, social, and global). Thirdly, some recent attempts initiated by the author and colleagues are explained as examples of the Hearts-On approach to science education. In particular, a series of community-based science programs led by SNU and the development of a series of books on 'Contextual Physics' (i.e. Body Physics, Wearing Physics, Dining Table Physics, and Sports Physics) are outlined. Finally, the idea of scientific humanism is explored in relation to the context-rich approaches in science education. It is hoped that this paper helps us to reconsider how we can expand the world of science education beyond the boundaries of the curriculum and school and into a more humanistic one.

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