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Need and Significance of STS Education at the University Level

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Abstract: The study purported to develop STS education course material at the university level in order to enhance science literacy and understanding of the relationships among science, technology and society. A developed STS course was provided to 265 freshmen and sophomore students, majoring in the Humanities and the Social Sciences, the Natural Sciences and Engineering, and Fine Arts. Students participated in the survey examining changes in students' attitudes toward and perspectives on STS before and after the implementation. Ten questionnaires were selected from VOSTS for the survey. One additional questionnaire asked the students to elaborate their opinions on the need for a STS education course. The responses to the survey were analyzed according to types of questions and students' majors. As result, the developed STS course significantly increased students' science literacy. Among the participants, 97.7% responded that there is a need for STS education and provided reasons for such need. These results imply that there is a definite need for a STS class at the university level. According to the analyses of responses, there were different responses depending on the students' major. These differences imply that the major, academic background, level of interest in science, and knowledge of science of the students affect their perceptions on identifying the need for a STS education course.

Key words: STS education, STS course, attitude, perceptions

I. Introduction

The goal of today's science education is to enhance the understanding of nature and the interactions among science, technology, and society (STS) (Vazquez-Alonso, Manassero-Mas, 1999). With this new perspective towards science, people need to be aware that science is no longer a separate subject from society, but plays a vital role within the socio-cultural context (Ziman, 1980). STS has become a major trend since the 1980s (Roy, Waks, 1985). STS has long been an internationally recognized subject area, and efficient STS education materials and programs have been developed in accordance with this interest (Choi, 1996). In Korea, STS was introduced with the 6th Curriculum in 1992 at the elementary and secondary school levels (Jung *et al.*, 1993). STS was even more emphasized in the 7th Curriculum, as it was stated that STS could meet the four major educational objectives of National Common Basic Curriculum. With this idea, "Living and Science" within the high school curriculum based itself on the STS perspectives (Cho, Choi, 2000).

However, in Korea, there are not many classes offered which pertain to STS related issues and topics, and only a few universities offer such classes. As a consequence, there is a lack of education on the historical, philosophical, ethical and cultural aspects of science in the educational setting (Choi, Kim, 2001). In some western countries, STS-related classes have long been offered at the university level: the material in these classes is constantly updated according to the current social issues in science and technology (Fullick, Ratcliffe, 1996). This prominence of STS-related classes in some western countries sharply contrasts with the situation in Korea.

Modern science changes rapidly and has elicited many changes in epistemological, social, ethical perspectives; as a result, these science-related issues have attracted the attention of people striving to be informed decision-makers (Choi, Cho, 2001). In order for people to develop such informed

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perspectives, they need to gain understanding of the interactions among science, technology and society. This necessity implies the need for continuous science-related education from elementary school all the way through the college level (Hurd, 2000). Bradford *et al.* (1995) stated that other science-related classes are not able to meet the objective of enhancing STS literacy; therefore, classes specifically teaching topics on STS should be developed and offered at the university level. This study purports to develop a STS course in order to enhance college students' STS literacy and understanding of the nature of the science of technology; furthermore, this study examines the changes in the students' perspectives on STS after the course implementation.

II. Methods and Procedure

1. Participants

A total of 265 freshman and sophomore students at a Korean women's university participated in the study. As shown in Table 1, there were 102 freshmen (38.5%) and 163 sophomores (61.5%). Regarding their majors, there were 178 (67.2%) Humanities and Social Science majors, 47 (17.7%) Natural Science and Engineering majors, and 40 (15.1%) Fine Arts majors.

2. Development of course material

The purpose of the course material was to improve understanding of science-technology-society within a sociocultural context and to focus on the nature of science. The educational objectives of the course material included raising comprehensive understanding of science in human lives rather than just theory-based learning, which will eventually enable the person to utilize and apply scientific knowledge appropriately with regards to social or personal issues related to science. The course materials were comprised of the topics and themes shown in Table 2.

The course materials were developed by three science educators fully utilizing visual aids such as pictures, images, video materials showing actual cases and phenomena to assist the students' understanding. Depending on the theme, the course materials also included related activities such as watching videos and listening to lectures by experts.

The evaluation was administered through a written self-report and a group project. The group project was evaluated by submitting a full report on the process of selecting a social topic related to science, investigating the issue, having debates on various perspectives, and finally reaching a conclusion.

3. Measurement Tool

VOSTS, which was used in this study as a measurement tool, was developed through six years of field research to examine students' views and perspectives on STS by Canadian researchers, Aikenhead, G.S., Ryan, A.G., and Fleming, R.W. in 1989. VOSTS focuses on measuring students' views on STS from the cognitive perspective rather than the affective perspective. VOSTS is composed of 114 multiple choice items, and it can be used adaptively depending upon which areas the researcher wishes to focus (Aikenhead, Ryan, 1992).

In the study, 10 items were selected from each of the subcategories of VOSTS in order to examine the changes in the students' perspectives (Table 3). As shown in the table, these ten items are multiple-choice questions with 5-8 responses. The responses can be classified into three categories: the first category contains responses with appropriate views based on the realistic perspectives (*realistic*); the second category contains responses which, while not realistic, possess legitimate points (*has merit*), and the third category contains responses that express inappropriate or unfounded views (*naive*). In this study, two science educators reviewed the categorization of the students' responses. As displayed in Table 4, points of 2, 1, 0 were assigned to the responses in the respective categories of *realistic*, *has merit*, and *naive*. Such a scoring system for each item in the VOSTS was also used in the studies by Rubba *et al.* (1996) and Noh, Kang (1997). Furthermore, as the scores for each category were not on an interval scale, it was decided to use

Table 1

Distribution of students based on grade level and major

Level \ Major	Humanities and Social Science	National Science and Engineering	Fine Arts	Total
Freshman	83 (31.3%)	16 (6.0%)	3 (1.1%)	102 (38.5%)
Sophomore	95 (35.8%)	31 (11.7%)	37 (14.0%)	163 (61.5%)
Total	178 (67.2%)	47 (17.7%)	40 (15.1%)	265 (100.0%)

Table 2

STS course content outline

Week	Themes/Topics	Content
1	The Nature of Science	1) The properties of science: The definition and components of science 2) Scientific methodology: induction, deduction, hypothetical deductive method 3) The purpose and value of science
2	Origin of Science / Science in Middle Age	1) The origin of science and the formation of modern science 2) The early stage of natural science growing in the Mediterranean Sea 3) The developments and characteristics of ancient science 4) The science and technology of the middle ages
3	Change of Views on Nature / Scientific Revolution	1) Views of nature and the development of science 2) Copernicus' astronomy 3) The time for scientific revolution 4) The Newton's Principia and completion of classical mechanics
4	Science and Changes of Thought I	1) The change of thought by continental drift theory 2) The change of thought by evolution theory
5	Science and Changes of Thought II	1) The change of thought by the theory of relativity 2) The change of thought by quantum theory
6	Changes of Human Life I	1) The change of life by the development of information technology 2) The change of life by biotechnology
7	Changes of Human Life II	1) The change of life by the development of meteorological technology 2) The change of life by the development of environmental technology 3) The change of life by semiconductor and superconductor
8	Cosmos and Chaos	1) The nature of cosmos and chaos 2) Chaos in cosmos, cosmos in chaos 3) The harmony of cosmos and chaos
9	Issues in Science and Society	1) Issues of war and society 2) Disease and life
10	High Technology and Future	1) Nanotechnology 2) Cyborg
11	Energy and Future	1) The advanced materials and the future of human 2) The global warming and the alternative energy development
12	Life and Future	1) Organ transplantation and the artificial organs 2) Life replication and morality
13	Mystery of the Universe	1) The origin and history of the Universe 2) The construction of the Universe 3) The exploration of the Universe 4) Extra terrestrial
14	The End of Science	1) The end of Science: Developments and limits of science 2) The scientific technology and humans of the modern society
15	Summary and Final Exam	

Table 3
VOSTS Categories and Items

Category	Subcategory	Items
Definition	Ⅰ. Science and technology	1. Defining science is difficult because science is complex and does many things. But MAINLY science is:
External Sociology of Science	Ⅱ. Influence of Society on Science/Technology	2. Some cultures have a particular viewpoint on nature and man. Scientists and scientific research are affected by the religious or ethical views of the culture where the work is done.
	Ⅲ. (future)	
	Ⅳ. Influence of Science/Technology on Society	3. Korean scientists should be held responsible for the harm that might result from their discoveries. 4. In your everyday life, knowledge of science and technology helps you personally solve practical problems (for example, getting a car out of a snowdrift, cooking, or caring for a pet). 5. More technology will improve the standard of living for Koreans.
	Ⅴ. Influence of School Science on Society	6. Science classes have given me the confidence to figure things out and decide if something (for example, an advertisement) is true or not. Because of my science classes I have become a better shopper.
Internal Society of Science	Ⅵ. Characteristics of Scientist	7. Today in Korea, there are many more male scientists than female scientists. The MAIN reason for this is:
	Ⅶ. Social Construction of Scientific Knowledge	8. When a new scientific theory is proposed, scientists must decide whether to accept it or not. Scientists make this decision by consensus; that is, proposers of the theory must convince a large majority of fellow scientists to believe the new theory.
	Ⅷ. Social Construction of Technology	9. When a new technology is developed (for example, a better type of fertilizer), it may or may not be put into practice. The decision to use a new technology depends on whether the advantages to society outweigh the disadvantages to society.
Epistemology	Ⅸ. Nature of Scientific Knowledge	10. Even when scientific investigations are done correctly, the knowledge that scientists discover from those investigations may change in the future.

Table 4
Categories of student responds and scoring system

Category	Meaning	Score
Realistic	The choice expresses an appropriate view	2
Has Merit	While not realistic, the choice expresses a number of legitimate points	1
Naive	The choice expresses a view that is inappropriate or not legitimate	0

the Wilcoxon test, a non-parametric statistical tool corresponding to a parametric statistical tool for matched sample t-tests.

Pre- and post-tests were administered before and after the implementation of the course material on STS in order to examine the changes in STS literacy. If the students had different views from the given responses for the item, they were asked to provide a descriptive response to elaborate their thoughts or opinions after marking "None of the above" as done in the study by Noh, Kang (1997). The accuracy of the translations were revised and approved by two science educators. The tool was pre-administered to ten students in order to measure their levels of understanding and appropriateness and revisions were made accordingly.

In addition, students were also asked to express their opinions on the need for STS education at the university after the implementation of the STS course. The students' descriptive responses on the need for STS education were analyzed in two steps.

First, the students responded either "yes" or "no," and the frequencies of these answers were counted respectively. Secondly, the students' descriptive responses on the reasons for their opinions were analyzed and then categorized together with similar answers and their frequencies were counted. As many students provided more than one response, multiple response analyses were used.

III. Results and Discussion

1. Changes in Students' STS Literacy after Course

As shown in Table 5, the average of the responses before the STS course is 14.18 and after the implementation, the average is 14.95; this significant difference between these scores ($p<0.001$) indicates that the implemented STS course brought about the improvement in STS literacy.

Table 5
Wilcoxon test analysis of the Mean Change Scores for the total students

	pretest		posttest		
	Mean	Standard Deviation	Mean	Standard Deviation	Z
total	14.18	2.43	14.95	2.21	4.385***

***p<0.001

As illustrated in Table 6, among the changes in the 10 items, item 4 and 6 had significant changes at the level of 0.01, and 0.001. Item 4 inquired about the students' ability to apply sciences' knowledge in everyday life, and item 6 inquired about the degree to which students utilize science knowledge learned at school when making judgments pertaining to science related issues. These results indicate that the implemented STS course has brought changes of perspectives on these two items(Table 6).

In terms of the changes in scores before and after the implemented STS course, based on the students' majors, each of the items had different significance levels. Among the Humanity and Social Science majors, items 4 and 6 had significant differences at the 0.05 and 0.01 levels. Also, item 1 had a significant difference at the level of 0.001, which inquires about "understanding definition of science"

Table 6
Wilcoxon test analysis for item response (n=265): Total Students

	pretest		posttest		
	Mean	Standard Deviation	Mean	Standard Deviation	Z
1	1.36	0.54	1.41	0.54	0.990
2	1.63	0.64	1.69	0.59	1.075
3	1.29	0.74	1.38	0.71	1.746
4	1.25	0.53	1.37	0.54	3.136**
5	1.81	0.41	1.80	0.42	0.351
6	1.10	0.83	1.33	0.79	4.077***
7	1.89	0.40	1.93	0.32	1.151
8	1.48	0.88	1.58	0.81	1.729
9	1.07	0.80	1.14	0.79	1.200
10	1.30	0.59	1.32	0.63	0.309

**p<0.01, ***p<0.001

(Table 7). This result indicates that the implemented course on STS had more effect on students majoring in the Humanities and Social Sciences rather than those in the Natural Sciences and Fine Arts, considering the fact that the other majors did not show a significant difference regarding these items. In contrast, students with Natural Science majors showed a significant difference only in one, item 6, as shown in Table 8. This finding suggests that the STS course helped Natural Science majors to have better judgment and decision-making perspectives on science-related social issues. After the implementation, the students majoring in Fine Arts registered significantly different responses on items 4 and 6 at the levels of 0.05 and 0.01 respectively; however, for the item concerning the understanding of the definition of science, the score for the Fine Arts majors decreased significantly at the level of 0.01 (Table 9). In the pretest, the responses of the Fine Art major students on item 1 were 23 (57.5%) realistic responses. However, in the posttest, the number of students who had "realistic opinions" decreased to 10 (25.0%) and those who had opinions categorized under "has merit", such as "to gain knowledge for making the world a better place (such as less disease, pollution, resolutions of agricultural skills, treatments, etc.)" scored the highest among the categories with 16 students (40.0%). This finding suggests that students majoring in Fine Arts had heightened their awareness of science and technology's role in society in creating better living conditions,

Table 7

Wilcoxon test analysis for item response (n=178): Humanity and Social Science major

	pretest		posttest		Z
	Mean	Standard Deviation	Mean	Standard Deviation	
1	1.28	0.52	1.43	0.53	2.92***
2	1.62	0.64	1.71	0.54	1.67
3	1.35	0.72	1.41	0.70	1.07
4	1.26	0.52	1.37	0.51	2.25*
5	1.86	0.35	1.80	0.41	1.54
6	1.08	0.84	1.28	0.81	2.71**
7	1.92	0.37	1.94	0.28	0.88
8	1.42	0.91	1.51	0.87	1.13
9	1.07	0.80	1.16	0.77	1.17
10	1.32	0.59	1.29	0.62	0.54

*p<0.05, **p<0.01, ***p<0.001

Table 8

Wilcoxon test analysis for item response (n=47): Natural Science and Engineering major

	pretest		posttest		Z
	Mean	Standard Deviation	Mean	Standard Deviation	
1	1.36	0.54	1.41	0.54	0.57
2	1.63	0.64	1.69	0.59	0.61
3	1.29	0.74	1.38	0.71	1.04
4	1.25	0.53	1.37	0.54	0.81
5	1.81	0.41	1.80	0.42	1.41
6	1.10	0.83	1.33	0.79	2.22*
7	1.89	0.40	1.93	0.32	0.00
8	1.48	0.88	1.58	0.81	0.83
9	1.07	0.80	1.14	0.79	0.19
10	1.30	0.59	1.32	0.63	0.67

*p<0.05

Table 9

Wilcoxon test analysis for item response (n=40): Fine Arts major

	pretest		posttest		Z
	Mean	Standard Deviation	Mean	Standard Deviation	
1	1.53	0.60	1.20	0.52	2.71**
2	1.80	0.52	1.63	0.67	1.33
3	1.35	0.77	1.50	0.68	1.19
4	1.15	0.58	1.40	0.50	2.50*
5	1.78	0.53	1.80	0.46	0.28
6	0.98	0.83	1.35	0.74	2.70**
7	1.78	0.58	1.88	0.46	0.95
8	1.60	0.81	1.80	0.61	1.16
9	1.20	0.88	1.27	0.82	0.53
10	1.23	0.62	1.40	0.59	1.39

*p<0.05, **p<0.01

Table 10

Need of STS Education at University

	Needed	Not Needed	No Response	Total
No. of Responds(%)	259 (97.7)	2 (0.8)	4 (1.5)	265 (100)

instead of building well-rounded awareness of all the aspects of science.

2. Attitude towards the Need for a STS Course at the University

As shown in Table 10, 259 (97.7%) students responded that a STS course was "needed" at the university, two students (0.8%) responded that a STS course was "not needed", and four students (1.5%) answered "No Response". This result implies that students who participated in the STS course strongly believe that the course is needed at the university level.

Regarding the reasons the students provided for their answers, those who answered "not needed" did not provide descriptive reasons; however, those who answered "needed" provided reasons as shown in Table 11. The most counted reason at 30.1% was that "science has a strong relationship with individual's living and society". Next, 11.5% of the responses indicated that the education was needed "in order to expand thoughts on the role of science" and 10.9% responded "it gives change for non-science majors to think of science." "Others" included "to expand common sense," "to apply comprehensive knowledge of STS on other areas," "despite all of the practical examples, the nature of science is still difficult to understand."

Conclusively, the reasons students have provided for STS course implementation are consistent with the ones mentioned in the STS literacy inventory: to understand the nature of science, to gain knowledge on the relationship between science and society, to develop an informed opinion, and hence, be able to make sound judgments and decisions on social issues related to science with an informed opinion. The

Table 11

Reasons for STS Educations (Multiple responses)

Responses (%)

Responds Category	Humanity and Social Science	Natural Science and Engineering	Fine arts	Total
1. Science has deep relationship with our living and society.	63 (30.0)	16 (27.1)	15 (34.9)	94 (30.1)
2. In order to expand thoughts on science content and its role.	24 (11.4)	5 (8.5)	7 (16.3)	36 (11.5)
3. To provide an opportunity for non science related majors to consider the significance of science.	26 (12.4)	5 (8.5)	3 (7.0)	34 (10.9)
4. Science is the required elective for people living today.	22 (10.5)	7 (11.9)	3 (7.0)	32 (10.3)
5. To be able to have an appropriate perspective and attitude towards science as it is influential in our society.	18 (8.6)	6 (10.2)	2 (4.7)	26 (8.3)
6. To be able to play an appropriate role in science related social issues in decision making.	9 (4.3)	4 (6.8)	2 (4.7)	15 (4.8)
7. To be able to learn about science in an approachable way.	10 (4.8)	4 (6.8)	1 (2.3)	15 (4.8)
8. To learn scientific thinking.	13 (6.2)	1 (1.7)	0 (0.0)	14 (4.5)
9. To be able to predict and prepared for future social changes.	9 (4.3)	3 (5.1)	1 (2.4)	13 (4.2)
10. Others	15 (7.1)	5 (8.5)	5 (11.6)	25 (8.0)
11. No Responds	1 (0.5)	3 (5.1)	4 (9.3)	8 (2.6)
Total	210 (100.0)	59 (100.0)	43 (100.0)	312 (100.0)

most important finding from this study is that students are aware of the need to develop STS literacy, and that the implementation of a STS course will provide an opportunity for the non-science related majors to be exposed to essential knowledge regarding science and its significance in everyday life. The results also indicate that there is a need for a STS course capable of triggering curiosity and interest in science without "science phobia."

IV. Conclusions and Implications

The developed STS course in this study had a significant effect in enhancing science literacy in students at the university. Among the students that participated, 97.7% responded that such a course is needed at the university as an elective course, the reason being that knowledge of science is the basic literacy of the people living today, as mentioned in the STS literacy inventory. This result strongly supports the need for STS education at the university. Specifically, there were different results depending on the students' majors and types of questions. Regarding "understanding science," there was a significant change for the students majoring in the Humanities and the Social Sciences, no significant change for the Natural Science and Engineering majors, and a significant decrease shown among the Fine Art majors. Regarding the items asking "students' ability to apply science-related knowledge when decision making social issues related to science," and "the degree to which students can utilize the scientific knowledge, methods and facts learned at school when interpreting or understanding social issues", both the Humanities and Social Science majors and the Fine Arts majors showed significant increases in the score; however, the Natural Science and Engineering majors showed significant increases only on the latter item. Based on these results, one could argue that a STS course covering various areas and depths of science-related knowledge is essential according to the students' level of understanding in science and their interest areas. Among the reasons provided for STS education, one stated, "it was easy to understand the relationship between Science-Technology-Society, although the nature of science was difficult to understand." Such a response supports the statement that STS education is essential, practical, and needed.

People need to gain science-related knowledge in order to live in modern society, and such a call should be met with proper education not only at the elementary and secondary educational level, but also at the level of higher education. This implementation would further enhance interest in STS and facilitate research as well. With these educational improvements, educational institutes and schools would better be able to meet the demands of society, and would further develop materials for comprehensive education in STS.

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