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Full Length Research Paper

A science–technology–society paradigm and Cross River State secondary school students' scientific literacy: problem solving and decision making

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The aim of this study was to investigate the effect of Science-Technology-Society (STS) curriculum on students' scientific literacy, problem solving and decision making. Four hundred and eighty (480) Senior Secondary two science and non-science students were randomly selected from intact classes in six secondary schools in Calabar Municipality of Cross River State. The experimental and control groups each comprised 120 science and 120 non science majors randomly assigned to them. The experimental group was exposed to researcher designed and validated Curriculum in Science-Technology-Society (COSTS) for 24 weeks at 2 h per week. The control group followed the normal existing science curriculum. A quasi experimental factorial design was used to identify the effect of COSTS if any scientific literacy, problem solving and decision making ability in coping with socio-scientific issues. The Test on Science-Technology-Society (TOSTS) was administered to both experi-mental and control groups. The data obtained were subjected to statistical analysis using covariance and the result emerged that students taught using the COSTS performed significantly better in scien-tific literacy, problem solving, and decision making than students who were not exposed to COSTS materials. This study highlights the need for an alternative science curriculum that will make students to be scientifically literate, problem solvers, and rational decision makers in a society riddled with science and technological problems.

Key words: Curriculum, scientific literacy, problem solving and decision making.

INTRODUCTION

Most of the changes and achievements of this century are based on the use of science and technology. Science and technology not only modify our physical environment but they also colour our perception and influence our decisions. Science and technology provide human beings with a hitherto unparallel capacity to control the material world. This power can be used both creatively and destructively.

Scientific and technological activities are exerting a great influence on Nigeria's essentially traditional culture. As Mesthene (1970) rightly argues, "technological change is outstripping traditional methods of analysis in the same way as it is rendering obsolete many established institutions and values of society". He goes further to outline the full dimension of the vast upheaval around us, clearly defining both its positive and negative aspects. He argues for a response that will make man a master rather than a slave of science and technology.

Science was to give us true knowledge and liberate us from superstition and ignorance, and the technology which was to be derived from science would provide us with control over the material world. With this control, we would be liberated from hard work, hunger, poverty, inadequate housing, poor health etc. and by eliminating material scarcity it would eliminate causes of conflict and bring us peace (UNESCO, 1986).

Nevertheless, in this millennium we are in, the people in the developing countries of Africa, still await the benefits of science and technology that promised to ease their pains, feed their hungry, and reduce their burdens of labour. That promise is yet to be fulfilled in its entirety. Material conditions remain severely restricted for many people in Nigeria for which the promise might sound peculiarly empty.

It is believed that the promise is a genuine one, even if its fulfillment is only a possibility, it should be understood that social conditions necessary for that desirable results are yet to come about. Or rather, there is the need to grasp the complex interaction for the necessary social, material and technological conditions for science and technology to provide the real progress, which they make possible.

It is a well-known fact that the industrially advanced countries have harnessed the fruit of science and technology through innovations and the accruing economic benefits have helped to provide social and political stability. However, in a developing country like Nigeria, the reverse is the case. The country is yet to create the necessary scientific culture (The term culture is used here in a less classical sense) comparable to the developed world, in which the general public is made aware of the need to use scientific methods in their daily operations. This is not the same thing as asserting that even in the so-called advanced world, every citizen uses this approach.

One would have expected that in this era of stupendous scientific and technological development, science and technology would be completely woven into the fabrics of the Nigerian culture such that the citizens would imbibe the values derivable from these enterprises. Unfortunately, despite the marvel of science and technology, the nation appears not to have perceived science in its social, historical, and philosophical context.

It is for this fact that some science educators have observed that formal education has failed to develop positive attitude to science and scientists even among people who recognize that science has done great things (Kahle, 1976, 1977; Yager, 1978).

With respect to science education and its achievement in Nigeria, it could well be described in Hurd's (1983) words that "we are raising a new generation (of Nigerians) that is scientifically and technologically illiterate". In a similar vein, Slaughter (1983) warned of a growing chasm between a small scientifically and technologically elite and a citizenry ill-formed, indeed uninformed on issues with a science component. This 21st century will demand citizens who have the savvy to explore, understand, and to some degree, control their own fate in a society increasingly shaped by science and technology.

Undoubtedly, the use of science and technology is the key to economic and social emancipation for the developing countries. Equally important, however, is having a citizenry sufficiently literate enough to make the appropriate political, economic and social decisions about science and technology. In an age of rapidly changing technology, a society which is to function effectively needs people with a combination of cognitive abilities and affective qualities which make them both able and willing to inform themselves on issues with a scientific and technological content as best as they can, and as at when such issues arise.

An important educational objective to be realized is the ability to be flexible and adaptable. This is critical in preparing the youths to cope with societies whose long term needs and skills are still unknown. As technological changes may render certain specific skills obsolete, the objective of learning how to learn assumes additional importance.

No matter at what stage of development a certain country may be, the major aspirations, expectations, social values as well as frustrations of its people resemble those in advanced countries, at least in their nature, if not in their intensity, difference in emphasis, orientation or priorities that can be traced back to socio- economic and cultural factors. Therefore, efforts need to be exerted in the direction of making science and technology responsive to current conditions and the projected economic and social needs of the country.

It is in the light of the foregoing issues that this study was conceived.

STATEMENT OF PROBLEM

Science and technological progress have altered the educational requirement of dynamic and emerging societies. Nigeria and most of Africa are blessed with rich natural resources, good soil, forest, minerals, petroleum and so on. Ironically, however, there is shortage of skilled scientific and technological manpower. In order to develop and adapt to changes for the utilization of better and more efficient techniques, machinery and equipment, we need professional and technical know-how.

The valuable role of science in the development of a nation is never in dispute. Jegede (1983) has observed that the current development in science and technology have so greatly affected the lives of every human being that to be ignorant of the basic knowledge of these developments is to live an empty, meaningless and probably unrealistic life.

Therefore, a nation without a scientifically educated citizenry cannot be expected to make any reasonable technically based political decision on such issue as nuclear energy and atmospheric pollution because of lack of the rudimentary tools to grasp the various arguments. Therefore, to teach the young people science is to educate the society's future scientists and thus lay the foundation for a scientifically aware polity and a general public informed on scientific matters that affect the citizens' lives from day to day.

Ignorance or fear of science and technology will surely enslave Nigerians into 21st century serfdom.

"Technopeasants" according to Prewitt (1983) are people bewildered or intimidated by the new techniques and language, of science and technology. Techno-peasants are outsiders in their own society. By contrast, savvy citizens are those "in-the- know" acts upon a shrewd understanding of how the system works. Prewitt (1983) goes further by stating that:

The scientifically savvy citizen … is a person who understands how science and technology impinge upon public life. Although this understanding would be enriched by substantive knowledge of science, it is not conterminous with it. A savvy citizen understands the social context of science and technology.

He or She will recognize that scientific research is immersed in moral reasoning and political dynamics whenever:

The research competes for funding with other social activities;
The researcher's social goals linked to corporate profits, political prestige or to military strength, and the implications of the research raise social issues and affect social polity (Aikenhead, 1988). Thus savvy citizens will be as conversant in ethics as they are in politics.

Empowerment rests on an ability to make decisions. Wise decisions tend to be those based on pertinent knowledge and well-reasoned ethics (Gosling and Musschenga, 1985). All decisions arise from both knowledge and values. Savvy citizens will make their decisions thoughtfully by bringing their pertinent knowledge into focus with the values that guide their decisions (Aikenhead, 1985).

Hurd's (1988) conception of literacy underscores the independent interpretive use of what is learned by students in science education.

As a teaching goal, science and technological literacy translates into the ability of a student to interprets science and technological achievement and deficiencies in terms of the human and social forces that generates and sustains them.

Unfortunately, evidence abound of the fact that science education in Nigeria appears to be bedeviled with very serious travails, such as dwindling enrollment and poor achievement at the secondary level. This situation has become a matter of serious concern to science educators. Several studies have been carried out to determine the trend (CESAC, 1963; Obioha, 1967; Cole, 1975; Ipaye, 1975; Orisaseyi, 1976; Bajah, 1977; Egbugara, 1980; Onwu, 1986, 1987; Ogunniyi, 1979, 1980, 1981; Abdullahi, 1983). Most science educators agree on a long list of problems, which beset science in our schools. Generally, the problems in school science can be summarized with the following statements:

Over 90% of all science teachers use a textbook in excess of 90% of the time. The text is the source of information to be learned; it is the source of teachers' question for quizzes and examinations, ideas for activities.
Most information in science courses are justified as necessary before one moves to the next course, rarely however, is this the actual case.
Impact of science information in the lives of students and any application of the concept for student and/or society in general are omitted. It is assumed that impact and application will occur 'naturally' or that other teachers in other curriculum area will attend to this need.
Teachers view themselves as sources of information for students to learn. They rarely admit to not knowing; they restrict their students' interest and attention to a rigid course outline.
Evaluation is based on vocabulary mastery and recall of information from textbooks and/or teachers lectures.
Science is restricted to what occurs in a science classroom. There is rarely an emphasis upon extension of activities beyond the classroom or the school; it is rare to depend upon resources of any kind beyond the textbooks, the teacher the science room.
Problem-solving skill is merely given lip-service.
Teaching students to think for them, to be creative, to solve problems, appears inimical to Nigerian traditional culture (Onwu, 1990).

The prevailing attitudes and behaviour in the Nigerian society's teaching/learning process seems to be more consumptive rather than participatory.

Education should presumably prepare students to function effectively and independently in their lives. Thus, it should endow them with the cognitive and problem-solving skills necessary to deal flexibly with various problems encountered in daily-life and in professional occupations. It should also teach them skills on independent learning and imaginative thought so as to help them adapt to a changing world in the years after formal schooling. If we look at the actualities from the foregoing, we must admit that much of current education does not meet the preceding goal. In this light therefore, this study sought to find out the effect if any of Science-Technology-Society curriculum on secondary school students' scientific literacy, problem solving and decision making.

METHODOLOGY

Research design

The design used for this study was a quasi-experimental design. The design was a modification of the pretest-posttest test control group factorial design with one treatment variable and two moderator variables. Simply diagrammatized below.

Y_1 O_1 X O_2 (E)
Y_2 O_3 ~ O_4 (C)

Where E represents experimental group, C represents – control group, 0_1, 0_3 pretest performance, 0_2, 0_4 post test performance. Y_1, Y_2 represent the moderator variables.

Population and Sample

The population of this study consisted of all the Senior Secondary Two (SSII) students in all secondary schools in Calabar Municipality. A sample of six schools was selected through stratified random sampling from fifteen existing secondary schools in Calabar Municipality. A sample of 480 senior secondary two students was randomly selected from the six schools to form subjects of the study. A breakdown of the figure 480 gave 240 students in the experimental group and 240 students in the control group. Since SSII students are expected to offer or not to offer sciences, these two groups of subjects were studied (that is science and non-science majors). Thus a breakdown of the 240 SSII subjects in the experimental group gave 120 science major and 120 non-science majors. Likewise, the same numbers also constituted the science and non-science categories of the control group.

INSTRUMENTATION

The two instruments used for this study were:

a) The Curriculum on Science-Technology-Society (COSTS)
b) Test on Science-Technology-society (TOSTS)

a) Curriculum on Science – Technology – Society (COSTS)

a) The ultimate goal of COSTS was to significantly improve the scientific and technological literacy of students, because literacy is the empowerment to interact meaningfully and reasonably with one's environment. COSTS were designed to train students to construct their own meaning of their world related to science and technology.

The content of COSTS was built around five major themes namely:-

a) Epistemology and social content of science
b) Nature of technology and society – the ethnics and values of each; and the interaction between science, technology and society.
c) Characteristics of a scientist/technologist.
d) Social constructions of scientific and technological knowledge.
e) Problem solving and decision making on socio-scientific issues (that is science and technology, related social issues).

The development of COSTS followed a multi-stage sequence, which took advantage of the classroom realism as well known to teachers and students. First the researcher developed and taught the content of COSTS package using a pilot school. Based on this classroom experience the COSTS package was modified. The face and content validity of the curriculum on Science Technology-Society (COSTS) was ascertained by a group of expert. The face and content validity for items on the COSTS package were established by the panel of experts to be about 90% agreement. The final curriculum package was obtained after a critical appraisal, revisions and modification based on expert advice.

b) Test on Science – Technology – Society (TOSTS)

The test on science – Technology – Society (TOSTS) was designed to measure the following;

I. Acquisition of scientific and Technological literacy.
II. Knowledge of the interaction among components of science technology and society.
III. Problem solving and decision making abilities.

The instrument was divided into five sections:

Section A, dealt with demographic data of senior secondary two students viz: sex, age, religion, name and type of school, socio-economic status and area of study.

Section B, designated as the Nature of Science Test (NOST) was a 32 item, three option Likert type scale for each item, ranging from agreement, disagreement and no opinion. NOST was used to measure SSII students view on the Nature of Science and scientists.

Section C, designated Nature of Technology Test (NOTT) consisted of 35 statements on the nature of technology, bordering on the application, transfer or diffusion as well as practice of technology and its relationship with science. The instrument was a three option Likert type scale as the NOST.

Section D, designated as the Science – Technology – Society Interaction Test (STSIT) was a 25 item test to measure students knowledge of Science-Technology – Society Interactions. It allowed for a completion of expression, written paragraph responses and multiple choice items relating to the STS interactions.

Section E, designated as the Decision Making Ability Test (DMAT) was an instrument that required students to gather information, process such information and be able to choose between alternatives after evaluating the advantage and disadvantages of each choice. This instrument allowed subjects to work through simulation, case models, controversies/dilemmas that required different kinds of decision making viz scientific, technological, ethical, moral, and public policy. Guidelines for decision making were also provided for solving the various Nigerian based science and technology related social issues. Thoughtful or rational decision making was the major emphasis of this instrument.

Section F, designated as the Test of Problem Solving Ability (TOPSA) was a 12 item instrument used to monitor the reasoning mode of students. This instrument provided both the correct response option and matching reason in order to identify students who merely guessed answers since they will not be able to choose the correct reason. TOPSA was based on Lawsons; five reasoning mode viz identifying and controlling variables; combinational reasoning; probabilistic reasoning, correlational reasoning and proportional reasoning.

TREATMENT

The experimental groups were taught the content of the Curriculum on Science – Technology – Society (COSTS) designed by researcher using the mode of instruction suggested for STS materials (Aikentead, 1988) *The experimental groups were taught by the researcher and some classroom teachers. Enough precaution was taken

Table 1. Summary of descriptive statistics associated with the experimental and control subjects' Scientific Literacy, problem solving and decision making

STATISTICAL	NOST		NOTT		STSIT		DMAT		TOSTS		TOPSA	
	E	C	E	C	E	C	E	C	E	C	E	C
No. of cases	240	240	240	240	240	240	240	240	240	240	240	240
Pre-test mean	10.39	8.77	20.44	16.99	14.21	8.91	14.65	9.63	60.63	45.20	4.89	5.61
Pre-test SD	4.10	3.13	6.23	5.43	2.81	4.28	3.10	3.16	13.64	9.89	5.65	4.27
Post-test mean	26.78	15.13	29.36	24.33	36.60	18.75	39.19	20.65	133.44	80.02	42.91	18.85
Post-test SD	2.74	2.56	3.74	4.81	6.21	5.29	3.82	3.51	16.14	11.95	6.22	7.44
Mean gain	16.39	6.36	8.92	7.34	22.39	9.84	24.54	11.02	72.54	34.82	38.02	13.24
Adjusted post-test mean	26.61	15.29	29.13	24.57	33.87	21.49	39.02	20.81	129.69	83.77	43.04	18.72

KEY: Nature of Science Test (NOST); Nature of Technology Test (NOTT); Science-Technology-Society Interaction Test (STSIT); Decision-Making Ability Test (DMAT); Test on Science-Technology-Society (TOSTS); Test of Problem Solving Ability (TOPSA).

to minimize the effect of differences in teachers with an instructional guide for teaching science through an STS emphasis. The teachers also underwent a two day training workshop on the implementation of the STS curriculum.

The main emphasis in the STS curriculum units was on the development of skills in problem solving and decision making. Problem solving is an activity requiring individual to think logically and creatively as well as apply their knowledge and reasoning in decision making. The content of the COSTS package was taught to the experimental groups while the subjects in the control group were not taught the content of the COSTS but were allowed to experience their existing traditional science curriculum.

The treatment period lasted for 24 weeks at an average of 2 h per week for each experimental and control group. To ensure consistency in the teaching of the lesson, identical teaching plans that include all instructional materials needed for the activity were used by the researcher and the teachers.

To assume the equivalence and comparability of subjects in the experimental and control groups, pretest measure represented by 0_1 and 0_3 were used to compare the groups. The comparison indicated that the groups were not equal with respect to the variable of the study viz scientific literacy (F=251.32;p<.05), problem solving (F=489.15; p<.01) and decision making (F=10.51;<.01).
The result of the pre- entry behaviour with respect to selected variables has clearly shown that the groups were inequivalent at the start of the experimental treatment. The analysis of covariance was used to remove bias attributable to the experimental groups not being matched on some important characteristics and to increase the precision of the experiment by minimizing the error variance. Variables such as COSTS materials, test time, test and class level were held constant in an attempt to control for any effect they might otherwise have on the criterion variables.

The study was carried out during the second and third terms of 2003/2004 academic session. Each week comprised a 2 hour of STS instruction. After 12 weeks of experimental treatment, the post tests were administered after the experimental treatment. The same instruments TOSTS and TOPSA served both as the pretest and the posttest. Certain minor changes were effected on the test instruments to give a vague impression that the tests were essentially different from the one taken previously to guide against testing effect.

Based on the class attendance kept by the teachers and the researcher, only students who had received at least 80% of the instruction on the STS materials had the scripts scored and subsequently analyzed.

RESULTS

HO_1: There is no significant difference between the experimental and control students with respect to:

a) Scientific literacy
b) Problem solving
c) Decision making ability in the resolution of socio-scientific issues.

A 2 X 2 X 2: Analysis of covariance was conducted on the subjects posttest score in test of science. Technology – Society: Using the pretest scores as covariates; the result of the analysis presented in tables 1 and 2.

An examination of table 1 and 2 shows that experimental group outperformed the control group outperformed the control group with respect to cognitive achievement in scientific literacy (F = 996.02; P <. 01). Problem solving (F = 1822; P < .01) and decision making (F =

Table 2. A Summary of 2x2x2 Analysis of Covariance on the subjects' Posttest Performance Score on the TOSTS and its subscales

Measure	Source of Variation	Sum of Squares	Degree of Freedom	Mean Square	F	Significant of F
TOSTS: Test on science technology society	**Covariates**	**180110.716**	**1**	**180110.716**	**1005.481**	**.000***
	Main effects	179569.329	3	59859.443	334.153	.000*
	Treatment	178416.740	1	178416.740	996.024	.000*
	Sex	2.055	1	2.055	.011	.915
	Major	839.111	1	839.111	4.684	.031
	2-Way Interactions	958.221	3	319.407	1.783	.149
	Treatment	79.259	1	79.259	.442	.506
	Treatment major	498.836	1	498.836	2.785	.096
	Sex major	340.382	1	340.382	1.900	.169
	Explained	360719.961	8	45089.995	251.718	.000*
	Residual	84369.739	471	179.129	-	-
	Total	445089.700	479	929.206		
NOST Nature of Science Test	**Covariates**	**2183.789**	**1**	**2183.789**	**332.712**	**0.000***
	Main effects	14278.210	3	4759.403	725.120	0.000*
	Treatment	14045.373	1	14045.373	2139.888	0.000*
	Sex	20.452	1	20.452	3.116	0.078
	Major	40.467	1	40.467	6.165	0.013
	2-Way Interactions	47.656	3	15.885	2.420	0.065
	Treatment & sex	43.713	1	43.713	6.660	0.010
	Treatment & major	0.297	1	0.297	0.045	0.832
	Sex & major	1.802	1	1.802	0.275	0.601
	Explained	16567.535	8	2070.942	315.519	0.000*
	Residual	3091.457	471	6.564		
	Total	19658.963	479	41.042		
Nature of Technology Test (NOTT)	**Covariates**	**1050.393**	**1**	**1050.393**	**58.610**	**0.000***
	Main effects	2306.911	3	768.970	42.907	0.000*
	Treatment	2288.112	1	2283.112	127.395	0.000*
	Sex	18.727	1	18.727	1.045	0.307
	Major	7.565	1	7.565	0.422	0.516
	2-Way Interaction	131.531	3	43.844	2.446	0.63
	Treatment sex	63.612	1	63.612	3.549	0.060
	Treatment major	6.093	1	6.093	0.340	0.560
	Sex major	69.545	1	69.545	3.881	0.49
	Explained	3490.757	8	436.345	24.347	0.000*
	Residual	8441.141	471	17.922		
	Total	11931.898	479	24.910		

* Significant at .01
STSIT

1995; $p < .01$). This superior performance cannot be due to chance because, the calculated F – values of 996.02; 1822. 47 and 1995.98 were found to be greater than the critical F – value of 6.70 given 1 and 478 degrees of freedom and .01 alpha levels. The null hypothesis was thus rejected.

The F – value of 996. 02; 1822.47; 1995.98 were found to be greater than the critical F – value of 6.70 at 1 and 478 degrees of freedom and 0.01 alpha levels. The null

Table 3. A Summary of 2x2x2 analysis of covariance on subjects' post-test performance score on Test of Problem solving Ability.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F	Significance of P
Covariates	568.978	1	568.978	14.729	0.000*
Main effects	71210.247	3	23736.749	614.449	0.000*
Treatment	70403.703	1	70403.703	1822.469	0.000*
Sex	394.379	1	394.379	10.209	0.000*
Major	191.252	1	191.252	4.951	0.027
2-Way Interactions	812.191	3	270.730	7.008	0.000*
Treatments sex	783.294	1	783.294	20.276	0.000*
Treatment major	2.664	1	2.664	0.069	0.793
Sex major	0.180	1	0.180	0.005	0.946
Explained	72663.812	8	9082.976	235.122	0.000*
Residual	18195.180	477	38.631		
Total	90858.992	479	189.685		

Table 4. A 2x2x2 Analysis of Covariance of the subjects' decision making ability.

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F	Significance of P
Covariates	18947.742	1	18947.742	1390.163	0.000*
Main effects	27463.628	3	9154.543	671.653	0.000*
Treatment	27204.989	1	27204.989	1995.980	0.000*
Sex	162.052	1	162.052	11.889	0.000*
Major	701.017	1	701.017	51.432	0.000*
2-Way Interactions	363.807	3	121.269	8.897	0.000*
Treatments sex	19.737	1	19.737	1.448	0.229
Treatment major	321.198	1	321.198	23.566	0.000*
Sex major	38.671	1	38.671	2.837	0.093
3-Way Interactions	38.143	1	38.143	2.798	0.095
Treatment sex major	38.143	1	38.143	2.798	0.095
Explained	46813.321	8	5851.665	429.326	0.000*
Residual	6419.671	471	13.630		
Total	53232.991	479	111.134		

* Significant at 0.01

hypothesis suggesting that there will be no significant difference between the experimental and control groups in terms of scientific literacy, problem solving and decision making was thus rejected and the alternate hypothesis that there is a significant difference between the subjects in the experimental group and those in the control group with respect to scientific literacy, problem solving and decision making was retained. Table 5 shows that for scientific literacy, the amount of variance accountted for by treatment effect is 80.6% $(0.898)^2$ of the total variance. Similarly, for the problem solving, the table shows that 78.4% $(0.886)^2$ of the total variance is accoun-ted for by treatment effect. In the same vein, the multiple classification. Analysis presented in Table 3 shows that the amount of variance accounted for by treatment effect is 85.4% $(0.924)^2$ of the total variance.

Therefore, it could be concluded that the experimental group had a higher scientific literacy, problem solving ability and a superior decision making. *Capacity in coping with science and technology related social problems with those in the control group.

DISCUSSION

Based on the result obtained, the major hypothesis was rejected. The experimental group's superior performance illustrates the power of the STS curriculum over the traditional science curriculum to which the control group was exposed. No doubt, the former was at a greater advantage over the latter. In future studies efforts should be made to expose the latter to the STS materials in form of resource materials to be consulted along with regular tra-

Table 5. A Summary of multiple classification analysis of the scientific literacy, problem solving and decision making performance by experimental and control groups.

TOSTS NOST NOTT STSIT	Grand Mean = 105.521 Grade Mean = 21.133 Grand Mean = 27.092 Grand Mean = 26.824		TOPSA: Grand mean = 30.879 DMAT:Grand mean =			
Measure	**Variable + Category**	**N**	**Unadjusted Dev'n**	**Eta**	**Adjusted for Independence + Covariates Dev'n**	**Beta**
			TREATMENT			
TOSTS	1	240	26.71		22.96	
	2	240	-26.71		-22.96	0.75
	R^2			0.88		0.806
	R					0.898
			TREATMENT			
NOST	1	240	5.82	0.91	5.66	0.88
	2	240	-5.82		-5.66	0.835
	R^2					0.914
	R					
			TREATMENT			
NOTT	1	240	2.51	0.50	2.28	0.46
	2	240	-2.51		-2.28	0.279
	R^2					0.528
	R					
			TREATMENT			
STSIT	1	240	8.91	0.84	6.18	0.58
	2	240	-8.95		-6.20	0.828
	R2					0.910
	R					
Grand Mean = 30.879 Variable + N Category		**Unadjusted Dev'n**	**Eta**	**Adjusted for independents + covariates. Dev'n**		**Beta**
			Treatment			
1	240	12.03		12.16		
2	240	-12.03		-12.16		0.88
R^2			0.87			0.784
R						0.886
			Treatment			
1	240	9.73		9.44		
2	240	-9.73		9.44		0.90
R^2			.92	-9.44		0.854
R						0.924

ditional curriculum. This would help to eliminate possible influence of extraneous factors and ascertain the direct influence of the treatment.

This result could be further explained in terms of the fact that the STS curriculum takes into consideration the social context of science. It deals with values and social norms and thus has close-relatedness to the social science; the subject matter quite often constitutes means rather than goals; students are personally and actively involved in the learning process (Zoller, 1982).

The failure of the control group to perform as much as the experimental group supports the claim that school science today does not accurately represent the practice of science. Therefore, school science as it is presently taught may not be adequately communicating a true and realistic picture of either science or science related social responsibility.

Science and technology like all fields are social creations characterized by objectivity and subjectivity, logical thoughts and leaps of imagination, and many other human attributes and limitations known to society. Science has a human, political, ethical and economic context. By not taking these into consideration in the teaching of science in the schools, there is always the danger that the student will not acquire a critical view of scientific knowledge and practice. An absence of this contextual dimension in teaching can be as unwittingly hampering social responsibility, scientific literacy by interfering with thoughtful decision making (Aikenhead, 1980). As Desautel (1982) astutely put it:

By perpetuating overloaded curricula for years often poorly suited to the intellectual development of the majority of students, the system has guaranteed that only a minority will eventually have access to scientific careers… By divorcing curriculum content from everyday or cultural reality, the knowledge acquired is rendered useless for the individual in his or her daily action… By carefully avoiding the integration of the social problems related to scientific and technical development, generations of young people are prepared for a passive, naïve acceptance of what passes as progress.

The superiority of the STS group over the non-STS group in problem solving and decision making may not be unrelated with the nature of the task that the subjects are engaged in during treatment. The STS group was actively involved in tackling real life problem and decision making situations and experiences. "Doing" perhaps, is the real test of "Knowing" and so far, there appears to be no substitute for first hand experience (Zoller, 1982).

The poor performance of the control group in the problem solving and decision making tasks may not be unrelated to the educational inadequacies of the present science curricula. In order words, the traditional curricula do not seem to equip students with sufficient experiences necessary to make them capable problem solvers and decision makers. This is so because:

a) Students are not exposed to opened-ended socially-oriented problems, the solution of which calls for discriminating powers in applying value judgment.
b) The conflict of values in the real world (e.g the often violent clashes between personality, ideology or nationality, etc.) is ignored for the most part; since they occurs outside the confines of the school.
c) No deliberate attempt is made within most schools to develop decision making skills to be applied within our contemporary modern-technological context.
d) Curricula (especially science curricula) generally do not recognize the natural desire of youths to participate in the making of decision in the socio-technical domain (Zoller, 1982).

Consequently, many students are overwhelmed by the information inputs conveyed to them and of which they are ill-equipped to search out plausible solutions, originnate new ones, assess the results or implement any decision.

STS education deals with real issues, and so includes a demonstration of how values guide decision in science and technology related socio-cultural context. Crucial decisions are being made daily by people who are expected to consider scientific and technological knowledge along with the economic, political and ethical implications. This role of key decision makers pervades every society. This role perhaps, is not as clearly defined as the role of the professional scientist and technologists.

Conclusion

In conclusion STS is not just another "harmless", intellectual exercise. It is deliberate attempt to change students from being recipients of decisions made for them by someone else to one, which makes them active participants in the decision process in the real world situation. Many of the problems of life that beset individuals, and our country require an understanding of science of technology for their resolution. Because these problems are likely to persist, young people will be called upon to solve problems and make *actopm decision of that influence human being and the quality of life. The worthiness or otherwise of the decision reached on these subjects will depend to a great extent on the decision maker himself having a valid understanding of the nature of science and technology.

RECOMMENDATIONS

Based on the finding of this result, the following recommendations are made:

1) It is recommended that science education curriculum should be redesigned to:

Iintegrate science-technology-society themes, problems and issues in the overall curriculum;
Present a multidisplinary analysis of science and technology related problems;
Provide opportunities for informal learning;
Demonstrate relevance to the students' world;
Include computer literacy in the context of science knowledge, skills and values;
include decision-making components, that is, they should provide the students with both the opportunity to apply their judgment in choosing among alternatives.

(2) Science and technology teacher education should be redesigned to:

Encourage an increased use of inquiry, laboratory problem solving and decision making processes in the classroom.

Provide background in the historical, philosophical and social foundation of science and technology.

Enhance science teaching as a career.

Give professional organization like STAN, MAN, SAN a greater voice in setting standards for certification;

Include in the pre-service and in-service aspects of science teaching related to global problems and the STS themes.

(3) There is also an urgent need to train teachers adequately for the role they will be called upon to play in implementing desirable science curricula aimed at preparing the youths of today for the life of tomorrow that is science curricula that have social relevance.

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