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Attitudes toward Science: An Exploratory Survey of Pupils Preparing for National Examinations

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Abstract
This article reports on the findings of a survey of attitudes towards science of Grade 7, Form 2 and Form 4 pupils preparing to sit the November 1991 national examinations in Zimbabwe. Six hundred and twenty seven pupils obtained by a two stage sampling procedure from Harare Region comprised the sample for the study. Attitudes towards science were significantly different at the .05 level between either grade seven or form two pupils and form four pupils with pupils at the lower grade levels exhibiting significantly more favourable attitudes toward science compared to pupils at the higher grade level. Form 4 pupils as a group had a slightly negative attitude towards science. Differences in attitudes towards science were not detected when pupils were grouped according to gender. Implications for science educators and for further research are discussed.

Background

In general it is assumed that attitudes influence future behaviour and career choices (Yount and Horton, 1992; Mandebvu, 1991), are strongly related to achievement (Eichinger, 1992), and that they are sufficiently significant and relevant for science educators to be pre-occupied with (Schibeci, 1983). Significance of attitude studies is bolstered by observations that upon completion of course of study, "most cognitive learning will be forgotten, yet the general affect will remain" (Gogolin and Swartz, 1992, p. 501). In Zimbabwe, generally, the democratization of educational opportunity created implications that few pupils would likely find places in institutions of higher training and learning. Consequently, science education, particularly at secondary level, is expected to prepare the majority of pupils for the world of work (Ministry of Education and

Culture (MEC), 1992). MEC in the first decade following Zimbabwe's independence, initiated new science curricula envisaged to provide all pupils with an education which would be functionally useful in the world of work. School curricula , including science curricula, integrated education with production (EWP) thus helping pupils to relate knowledge and theory to their practical application in production in order to support national development efforts.

As in many other developing nations (UNESCO, 1983; Nichter, 1984; Chisman, 1984), science and technology (S & T) education is seen as a vehicle for economic and social advancement. Zimbabwe's *Five Year National Development Plan* (FYNDP) 1991-1995) states:

> Development of Science and Technology is Zimbabwe's *long term and most important strategy* for economic and social development *(p.84; emphasis added)*.

It would be desirable that such planning and expectations are based upon and presuppose that, while in school, pupils develop positive and favourable attitudes towards S & T so that they excel academically and so that they can willfully utilize this knowledge later in the productive sector as workers. Negative feelings or attitudes would be expected to discourage further exposure to scientific inquiry or to science-related careers and occupations (Gogolin and Swartz, 1992).

The rationale for the study was based on the assumption that monitoring attitudes of students completing courses of study can serve as a useful indicator of success of S & T curricula as well as an indicator of both scientific and technological potential and investment in the students. In North America, attitudes, in conjunction with achievement, have been used in order to estimate the condition of science in schools and in society for many years (Elkana, Lederberg, Merton, Thackray, and Zuckerman; 1978). It was essential in discussing the findings of the study to have an interpretive framework for the attitude construct in general and for science-related attitudes in particular.

The construct "attitude" consists of three components which interact and apply toward the attitude object to varying extents (Johnstone, 1982, Yount and Horton, 1992). These domains are the knowledge (cognitive), feeling (affective), and tendency to action (conative). According to Johnstone, and to Yount and Horton, the cognitive component of an attitude involved intellectual abilities that take into account the perceived relationships between the attitude object and other objects and/or concepts. The affective component indicated the degree of emotional attraction toward the attitude object while the conative refers to action or tendency to act in certain ways with regards to the object. This conceptual frame corroborates Shrigley (1983) and Schibeci's (1983) independent conclusions with regards to the attitude construct. According to both, attitudes involve cognition, are learned, predict behaviour, are affected by social influence of others, are a readiness to respond, and attitudes are evaluative involving emotion.

In light of the preceding operationalization of the attitude construct, when attempting to measure science related attitudes, it is imperative to distinguish "attitudes towards science" (ATS) from "scientific attitudes" and to clearly specify the aspect under study (Schibeci, 1983). Both scientific attitudes and ATS are explicitly articulated in the official science curricula for various levels in Zimbabwe. For example, Syllabus SS10 (ZIMB) 1992 attempts to instill qualities of objectivity, impartiality, a critical approach to information and ideas, and a respect for virtues of incisiveness and the quality of evidence, that is scientific attitudes. It also seeks to promote an appreciation of the role, importance and consequences of science both in the workplace and in the community, and thus purports to nurture ATS (p. 2). Attitudes toward science, which are the focus of this study, essentially and predominantly, have an affective orientation e.g. liking, enjoyment of the object 'science' unlike scientific attitudes which have predominantly a cognitive orientation e.g. objectivity, open-mindedness, etc. (Schibeci, 1983; Gogolin and Swartz, 1992).

The study

This study sampled students preparing to sit (in about eight weeks) the primary school, junior secondary, and high school level exit national examinations. It was assumed that ATS would serve as an indicator of students willingness and potential to acquire and utilize scientific knowledge and attitudes presumed essential in national , social and economic development (Elkana, et al., 1978, Yager and Penick, 1984 and 1986). Mandebvu's (1991) finding that pupils who elected science (and other school subjects) as their favourite school subject did so in relation to its perceived value and significance in the world of work suggests that students attitudes could predict effort and devotion in studying the subject, an important factor in determining achievement and in anticipation of science-related careers.

The study also sought to explore the differences in ATS between class levels and between sexes thus providing a replication of the Egglestone, Galton, and Jones (1976) study from which the data gathering instrument was adapted. In the Egglestone et al. study, students' attitudes were described and classified on five sub-scales indicative of different aspects of ATS ranging from a perception of science as a fun and enjoyable school subject to a personal commitment to science outside of school as a field of study or as career. The next section provides a more detailed description of the scales of the attitude toward science instrument (ATSI).

Instrumentation

The problematics of attempting to measure attitudes are articulated by Johnstone(1982) who bemoaned the trouble with poor and unreliable measuring instruments and the trouble shrouding construct operationalization. In order to minimize these problems, it was decided to adapt an instrument which had been previously tested and whose reliability was claimed to be relatively high (Egglestone et al., 1976) and which contained items the author could ascertain to be comparable to items in other instruments purporting to measure ATS (see for example Stafanich and Kelsey, 1989 and also more recently Gogolin and Swartz, 1992).

The instrument selected does not appear to contain items which might also be used to indicate 'scientific attitudes' and thus which might introduce both conceptual and construct validity problems (Gogolin and

Swartz, 1992). The ATSI appeared to contain simple and readable items suitable for grade levels in the study. It was also desired to have an instrument which in addition to yielding a single ATS score, would also yield composite scores corresponding to several different aspects of student attitudes.

The attitude instrument (ATSI) is therefore an adaptation of an instrument developed by Egglestone and others (1976) to measure personal affect towards chemistry, biology, and physics on British subjects. Considering that students in the present study studied Environmental and Agricultural Science (EAS) (primary school), General Science (junior secondary school), and Core Science and other elective science curricula (high school), the Egglestone version was re-written to evaluate attitudes toward science in general rather than a specific science discipline. While the original Egglestone ATSI consisted of 33 attitude items distributed unevenly on five scales, the adapted ATSI is 40-item fixed-response-format questionnaire comprising five scales with eight items per scale. Students responded to a four point system on the scale as follows: 1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree. The lower number on the scale represented agreement with the item on the scale and a more favourable disposition to that item. Such scale scoring was consistent with typical scale interpretations in Zimbabwe's education system where, in norm ranking or in rating individuals on achievement measures, smaller numbers such as "grade 1" or "division 1" represent higher and desirable achievement and larger numbers represent poorer and undesirable achievement. What effect this might have had in pupils' response sets was not determined.

While, typically, scoring involves summing items or sub-scale scores in order to indicate relative favourableness to the attitude object (Egglestone et al., 1976; Gogolin and Swartz, 1992), in the present study, for more absolute interpretation, an attitude was taken to be a measure on a continuum from strongly negative affect to strongly positive affect much like on the Thurstone scales (Ary, Jacobs, and Razavieh, 1985). A cut-off point of 2.50 on the scale was arbitrarily assigned to determine the transition from positive (scale score = or $<$ 2.50) to negative (scale score $<$ 2.50) and hence a mean score of 2.50 was, for interpretive purposes, viewed as the threshold limit for positive affect toward science.

In analyzing the data, an item such as "Science lessons are a waste of time" had the scores reversed since "strongly disagree" would reflect a high positive affect toward science. The five scales, two representative items per scale, and their relative interpretations are presented in Table I.

Methodology

The study utilized a two-stage probability sampling procedure to obtain a sample comprising 422 Grade 7 (G-7), 99 Form 2 (F - 2) and 106 Form 4 (F -4) pupils preparing to sit the November 1991 national examinations. It was desirable to make a comparison of these three levels because, traditionally, these grade levels represent typical schooling exit points. National examinations at this juncture usually determine progress to the next academic level and social role selection, especially for middle grade jobs in the case of the O level examination taken in Form 4 (see Lewin, 1984 for example).

Sample size was limited by costs and time available to the researcher to conduct and complete the study. Having determined from lists provided by the Harare regional offices of education that there were (in June of 1991) 218 primary schools, and 73 secondary schools, the first stage involved selecting five percent of primary and ten percent of the secondary schools by a simple random sampling technique. The sample thus consisted of 10 primary schools and 6 secondary schools all in Harare Region. As the secondary schools were being picked out from a table of random numbers, they were serially ordered so that the three (3) odd numbered schools were later used to draw the ZJC subjects and the three (3) even numbered, the O Level sample.

Table I:
Representative Items on Sub-Scales of the Attitude Instrument (ATSI).

Sub-Scales, Sample Items, and Interpretive Framework
Enjoyment of Science: The Fun Factor
I enjoy science lessons more than other lessons.
I look forward to science lessons.
A positive score on this scale suggests that pupils find the subject fun, an enjoyable activity, a part of the curriculum to be anticipated with pleasure, giving rise to a demand for more contact with the subject.
Perception of Practical Work: The Practical Investigator
It is fun to guess the outcome of science experiments.
I would rather work out how to do a science experiment than be told.
A positive score on this scale suggests that pupils enjoy the challenge of practical inquiry and doing practical work in the subject, and engage in speculation on the outcomes of practical inquiry.
Perception of Science Outside Class: Committed Scientist
I would like to be given a book or a piece of science equipment.
I like belonging to a science club.
A positive score on this scale suggests that pupils find the subject valuable

and worthwhile to pursue out of school in preference to other competing interests, and hence reflects a potential career aspiration.

Perception of Self-Involvement: Concrete Scientist

It is experiments in science that make me understand it.

I would rather do experiments in science than read about them.

A positive score on this scale suggests that pupils have a liking for practical work ,for presenting phenomena in non-abstract and more comprehensible form and for the opportunity it provides for personal involvement in doing science rather than teacher demonstration.

Motivation for Science Career: Career Scientist

I would like to become a scientist.
I would specialize in science if I had a chance.

A positive score on this scale suggests that pupils find parental approval for wanting a science-related career or occupation.

The second stage involved drawing the sample of students to participate in the survey from the schools that had been randomly selected in the first stage. From the ten primary and six secondary schools (three each F-2 and F-4 subjects, respectively),it was decided to select intact classes, one class from each school. The sample obtained based on voluntarily completed and returned questionnaires is shown in Table II. On average, based upon return rates and excluding non-respondents, the average class sizes were 42 at grade seven and 34 at the secondary level.

Table II also shows the distribution of respondents by sex. It must be observed that at the primary level, females comprise the majority (about 53%) but as the academic ladder is ascended, this group progressively diminishes reflecting, approximately, the undesirable national trend (Central Statistical Office, 1991). According to the Central Statistical

Office, many parents are likely to keep male students rather than female students in school, a trend that must be reversed in favour of equity.

Table II

Distribution of Subjects (N = 627)

Class Level	Sample (n)	Males	Female	% of Total
Grade Seven	422	199(47.2%)	223(52.8%)	67.3
Form Two	99	65(65.7%)	34(34.3%)	15.8
Form Four	106	70(66.0%)	36(34.0%)	16.9
TOTALS	627	334(53.3%)	293(46.7%)	100.0%

Results:

Data were analyzed using the Stat-View statistical package in order to provide answers to the research hypotheses in turn. Basing on the results of studies such as those of Egglestone et al. (1976), Yager and Penick (1984 and 1986), Yager and Yager (1985), Stefanich and Kelsey (1989), and others, several hypotheses were posed. First, it was hypothesized that ATS would be generally positive but would become less favourable in higher grade levels, and that females at all three grade levels would exhibit less positive ATS compared to males. Second, it was expected that female students unlike their male peers would have less favourable attitudes toward the practical and concrete scientist sub-scales. Third, females would tend more than males to exhibit lower science career expectations and that they would be less inclined to commit themselves to science outside of school basing on social role stigmatization and stereotyping against females (Egglestone et al., 1976).

Whenever appropriate, t-tests were used to assess differences in ATS between class levels and between sexes. Prior to any relevant t-test, for comparing differences between these group means, the F-test or analysis of variance was used to test homogeneity of the comparison groups in order to be able to select either the pooled or separate t-test (Hinkle, Wiersma and Jurs, 1988). In conducting both the F and the t-tests, the predetermined 0.05 probability level was used in order to reject or fail to reject the null hypotheses which postulated equality or no difference between comparison groups.

Overall attitude of pupils towards science

The major purpose of the study was to find out the attitude of students toward science, particularly those students who had completed or had nearly completed a specific level syllabus to be assessed through a public national examination. The intent was to explore the disposition of students towards science as a curriculum subject rather than to find out the scientific attitudes developed during and by studying science.

The results of analyzing the responses of the 627 pupils are presented in Table III. overall, G-7 and F-2 pupils reported a significantly positive and favourable disposition of science (mean$<$2.50). F-4 students had an overall negative ATS (mean = 2.60) and as a group, they tended to have greater spread in their attitude score (SD = 2.64) suggesting that pupils in this group consisted of pupils with strongly favourable and strongly unfavourable ATS. The data in Table III suggests that the order of favourable ATS was F-2$>$G-7$>$F-4. It is not clear why for this sample, attitude for the F-4s, who had greater exposure to science, show the relatively impoverished ATS in comparison to G-7 pupils whose exposure to science is fledgling (Lewin and Bajah, 1991; Shumba, 1992a). It is conjectured that this might be suggestive of the effect of teacher influence (Stefanich and Kelsey, 1989). In Harare region, secondary science teachers report on the lack of material resources in their schools to support hands-on inquiry and on their predominant reliance on less individual-activity oriented approaches to science instruction (Shumba, 1992b).

Table III

Class Level Mean Attitudes Toward Science (ATS)(N = 627)

Class Level	Mean	Std Deviation
Grade Seven (n=422)	2.05	2.09
Form Two (n=99)	1.96	1.98
Form Four (n=106)	2.60	2.64

School subjects that are the most liked and disliked

That subjects in the study had a favourable ATS is indirectly corroborated by the results of analyzing pupils responses to two items asking them identify the school subject they disliked the most (Figure I) and the one subject they liked the most (Figure II). A cautionary note must be sounded in interpreting the results in Figure I and in Figure II. While "science" is a universal curriculum offering in secondary schools, subjects such as"French", history, and various "technical subjects" reflect the unique curriculum to which the subjects in the sample had exposure in their respective secondary schools. Any comparisons at the subject level at the secondary level are limited to the actual schools in the sample and even within schools, to individual classes.

Two subjects, Mathematics and English which together polled 306 or nearly 73% of primary respondents, were the most liked by G-7 pupils. The least liked was Shona, identified by 200 or 50% of those responding. Science, specifically EAS, was the most liked by 54 G-7 respondents and most disliked by only 11. Of eighty two (82) F-2s identifying the most liked subject, 35(43%) listed "Science" . Sixteen liked "mathematics". The leas liked subjects Shona and History, which together polled 51 or 61% of the 83 F-2 respondents. The F-4 pupils did not appear substantially different from F-2s in their choice of most liked subject and hence their response to this item contradicts their overall ATS as depicted in Table III. Forty (or 44% of 91 responding) identified "science", 22 identified English and 6 listed mathematics. Only 9 or 12 % identified 'science' the most disliked subject.

Overall, science, as a subject in the curriculum of the respondents in this study does not appear to be a disliked subject. In fact, of the one hundred and fifty three (153) students identifying "science", 129 liked it the most, and only 24 disliked it the most.

A notable observation concerns the G-7 students in the sample. Respondents at this level identified the traditional subjects on the primary school curriculum, English and Mathematics, and hardly mentioned subjects such as Home Economics, Physical Education, Music, etc. which are recent "come-back" innovations. It is conjectured that these subjects have not started making an impression on the pupils at this level reflecting perhaps the little attention given to them in the schools from which the sample was drawn. This is a real possibility given the reported lack of curriculum and instructional leadership in these subject areas (Shumba, 1992a) and given the tradition of teaching and examining only in Mathematics and English.

Figure I: Distribution of Most Disliked School Subjects

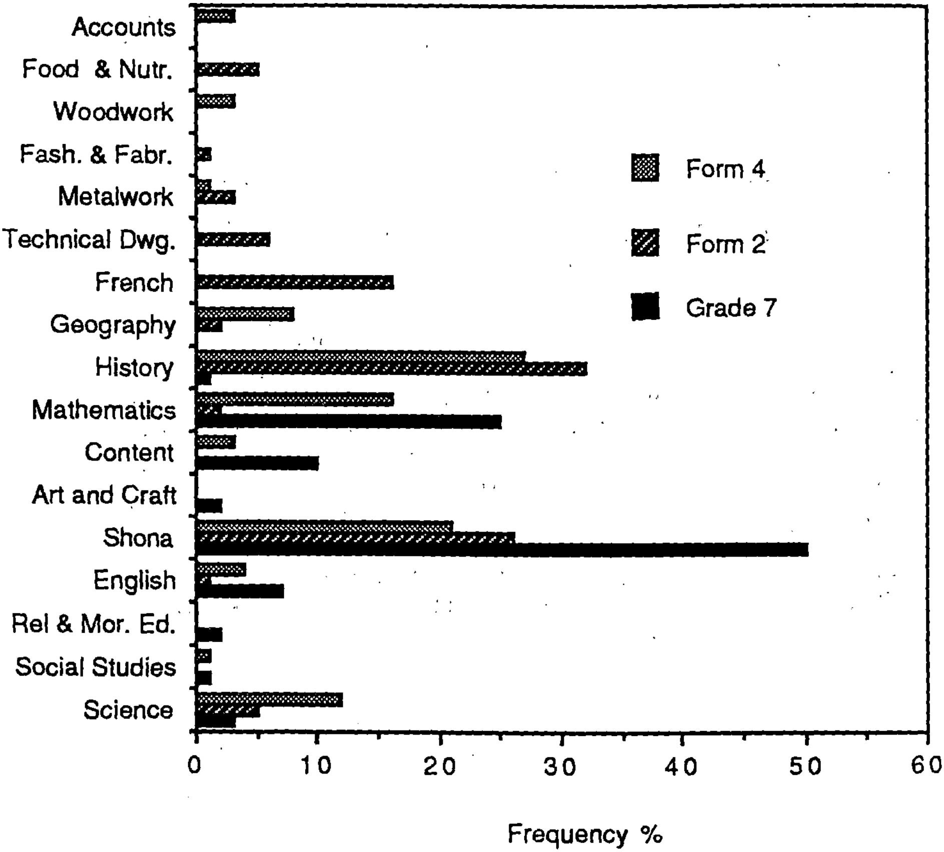
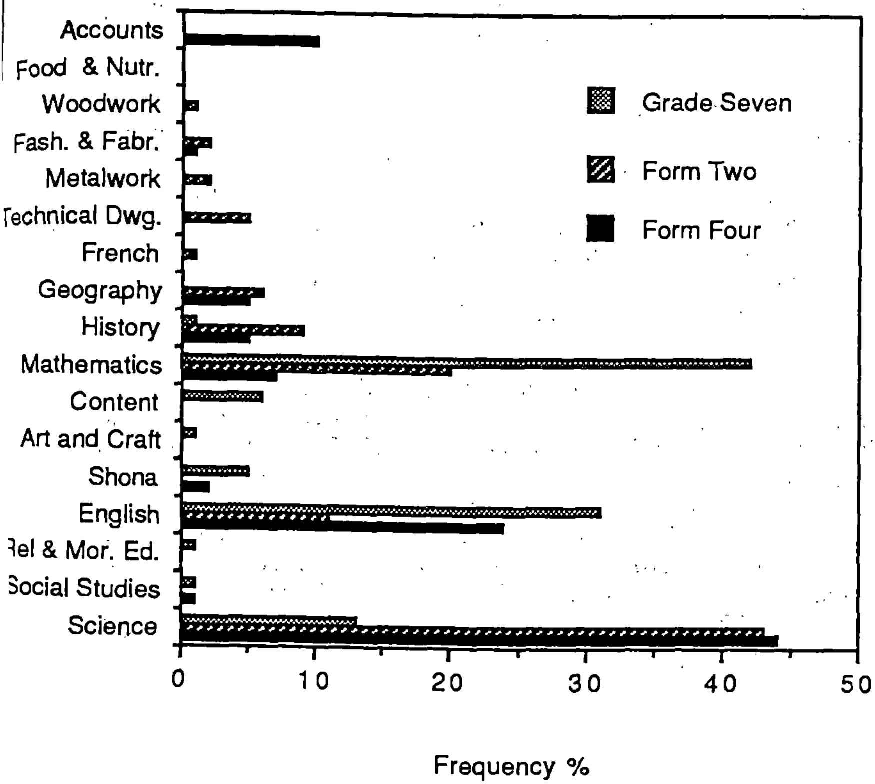


Figure II: Distribution of Most Liked School Subjects



Difference in ATS by class level and by gender

The results of analyzing attitudinal differences by class level and by gender are summarized in Table IV, Table V and Table VI. Table IV shows the results of the F-test of homogeneity of variance for the three class levels.

The results of the F-tests showed that the variance of the F-2s were not different from variance of the G-7s and thus a pooled t-test was conducted. The variance of the F-4 was significantly different from that of either the F-2 or the G-7 pupils and thus it was essential to proceed with a separate t-test. In the separate t-test, the Cochran and Cox formula for the estimate of the standard error of the difference between the means and the Statterthwaite formula to estimate the appropriate degrees of freedom were applied (Hinkle, et al., 1988).

Table V Shows the results of comparing the difference between class levels using the t-test. The ATS of F-2 pupils were not significantly different from the ATS of G-7 pupils ($t=0.4107, df=519$). Both G-7 ($=1.9537$) and F-2 ($t=6.0721$) pupils were significantly different in their ATS compared to F-4 pupils at the .05 alpha level. The junior secondary students exhibited the strongest attitude towards science followed by the G-7 students. The order of attitudes obtained, F-2 > G-7 > F-4, is not completely consistent with the prediction based on findings of the Yager and Penick (1984 and 1986) studies in which the predicted order would be G-7 > F-2 > F-4.

Table IV

Summary for F-tests on Variances of Pupil's Attitudes.

Class Level	Variance	F-test	Critical F	Significance
Grade Seven (n,422;df,421)	4.3681	1.1142	(p=.05;df=421;98) 1.32	p>.05
Form Two (n,99;df,98)	3.9204			
Grade Seven (n,422;df,421)	4.3681	1.5956	(p=.05;df=105;421) 1.24	p<.05
Form Four (n,106;df,105)	6.9696			
Form Two (n,99;df,98)	3.9204	1.7778	(p=.05;df=105;98) 1.48	p.<05
Form Four (n,106;df,105)	6.9696			

Note: The larger variance used in numerator for easy table determination of F.

In the present sample, G-7 students would be expected to have the least exposure to inquiry science although officially expected to have the exposure. Formal instruction in EAS, let alone inquiry-based instruction is severely limited at this level where primary teachers feel uncomfortable and even incompetent teaching science (Lewin and Bajah, 1990). Also at this level, there are no laboratory facilities and material resources to support EAS instruction, itself a recent innovation. A more logical order of ATS with the present sample would have been F-2>F-4>G-7.

Table V
t-Test Comparison of Attitudinal Differences Between Class Levels.

Class Level	Mean	t-test	Critical t	Significance
Grade Seven (n,422)	2.06	0.3107	(p=.05;df=519) 1.645	p>.05
Form Two (n,99)	1.96			
Grade Seven (n,422)	2.06	1.9537	(p=.05;df=526) 1.645	p.<05
Form Four (n,106)	2.60			
Form Two (n,99)	1.96	6.0721	(p=.05;df=203) 1.645	p.<05
Form Four (n,106)	2.60			

Table VI summarizes the results of analyzing gender differences in ATS. The F-test for variance between sexes yielded F-ratios that were not statistically (ns) significant for the appropriate degrees of freedom for each class level suggesting homogeneity of variance between sexes. The pooled one-tailed t-test was then used to test the hypothesis that male students would have more positive ATS than female students regardless of class level. All t-test values obtained were not statistically significant suggesting that there were no significant differences in ATS between sexes. The null hypothesis was thus retained ($p>.05$; Table VI) in contradiction to previously reported research findings (e.g. Egglestone et al., 1976).

Pupils' composite ATS

The study sought to replicate the Egglestone et al. (1976) study by investigating ATS differences based on five scales each measuring some different aspect of the personal affect toward science. The five sub-scales were interpreted in Table I as indicative of different aspect of ATS ranging from viewing science as a fun and enjoyable school subject to a personal commitment to science, outside of school, as a hobby or as a career. The results of analyzing the responses of each class level to each scale are summarized in Table VII.

Table VI

t-Test Comparison of Attitudinal Differences Between Sexes

Class level	Gender	Group Mean	F-Test and Sig	t-Test	Critica l t-value	Proba-bility
Grade 7	Male	2.05	1.20(ns)	0.049	1.645	p>.05
	Female	2.06				
Form 2	Male	1.97	1.02(ns)	0.024	1.671	p>.05
	Female	1.94				
Form 4	Male	2.56	1.07(ns)	-0.439	1.671	p>0.5
	Female	2.69				
Overrall	Male	2.14	1.11(ns)	0.528	1.645	p>.05
	Female	2.05				

Note: ns indicates F not significant for appropriate degrees of freedom.

Regardless of sex, F-2 and G-7 pupils have a positive attitude towards science to the extent that they value science outside of class and exhibit a motivation for a science-related career. They view science as "fun" and report a positive attitude to learning strategies that should be deployed in teaching science and thus fit the profiles of "practical investigators" and "concrete scientists" (refer to Table I). According to Egglestone's (1976) interpretive framework, these students have a demand "as yet not satisfied, for more contact with the subject" (p.89).

Table VII: Sub-scale Attitudinal Differences by Class Level and by Gender.

Class level		Fun Factor		Practical Investigator		Committed Scientist		Concrete Scientist		Career Scientist	
Class	*n*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std Dev.*	*Mean*	*Std. Dev.*
G-7	**422**	**1.94**	**2.0**	**2.16**	**2.2**	**1.98**	**2.0**	**2.26**	**2.3**	**1.95**	**2.0**
M	199	1.92	2.0	2.15	2.2	1.95	2.0	2.24	2.3	1.97	2.1
F	223	1.95	2.0	2.18	2.2	2.00	2.0	2.28	2.3	1.92	2.0
F-2	**99**	**1.78**	**1.8**	**2.05**	**2.1**	**1.93**	**2.0**	**2.24**	**2.3**	**1.81**	**1.9**
M	65	1.76	1.8	2.05	2.1	1.93	2.0	2.24	2.3	1.81	1.9
F	34	1.65	1.7	2.09	2.1	1.88	1.9	2.35	2.4	1.76	1.9
F-4	**106**	**2.65***	**2.7**	**2.81***	**2.9**	**2.43**	**2.5**	**2.73***	**2.8**	**2.37**	**2.4**
M	70	2.53*	2.6	2.69*	2.8	2.43	2.5	2.71*	2.8	2.43	2.5
F	36	2.89*	3.0	3.06*	3.1	2.44	2.5	2.75*	2.8	2.25	2.3
All											
M	334	2.03	2.1	2.24	2.3	2.05	2.1	2.33	2.4	2.04	2.1
F	293	2.03	2.1	2.27	2.3	2.04	2.1	2.35	2.4	1.95	2.1

*Significantly negative ATS (mean = or > 2.51, p = or < .05).

Note: 1. Class Level
- **G-7:** grade seven sample
- **F-2:** form two sample.
- **F-4:** form four sample.

2. Gender
- **M** : male
- **F** : female

An interesting finding pertains to the high school students (F-4) in the sample. They rated negatively the fun factor, the practical investigator and the concrete factor sub-scales but surprisingly rated positively the committed and career scientist sub-scales and therefore do not fit the description given to their juniors. This is a rather confusing result. First, it is always assumed that at all levels of the educational ladder a hands-on-practical-investigation approach to science would be more desired for favourable ATS to blossom. Second, it is not clear why they would rate more positively aspects that reflect a commitment to science, which supposedly should reflect that pupils find the subject valuable and worthwhile to pursue out of school in preference to other competing interests, and hence reflect a potential career aspiration (Egglestone et al., 1976). This should be a subject of further investigation to include elaborate scrutiny of the internal consistency of the ATSI itself.

However for all groups, positive responses to the "committed" and "career" scientist sub-scales was encouraging. First, if given a chance and opportunities, these students would belong to science clubs and would buy science books or equipment thus forgoing other competing interests. Second, if this commitment to science was to reflect in achievement and in later life career choices, then the nation would be assured of a consistent supply of would-be-scientists and scientifically literate work-force. It remains a challenge to capture and nurture this evident interest in schools by ensuring a regular and consistent supply of quality science teachers. Use of science clubs as a method of teaching science and as method of getting students interested in science is worth serious consideration (UNESCO,1983).

Discussion and Implications of Findings

While the result of this study are tentative and limited to the students involved directly in the study, several findings of the study warrant further discussion. Gabel (1981) indicated that the number of science courses taken may have a cumulative effect in positively influencing ATS exhibited by students. Contrary to this logical expectation, Yager and Penick (1984 and 1986) reported that for American students, ATS became less favourable with time spent in school and hence paradoxically with increasing exposure to science. The present study found that students in the lower grade levels (primary and junior secondary) exhibited significantly more positive ATS compared to students at high school.

Taking into account the findings of Yager and Penick, and the conditions and realities of science teaching in Zimbabwe, a more logical order of decreasing favourableness would have been junior high school, high school, and primary.In the present sample, G-7 students would be expected to have the least exposure to inquiry science although officially expected to have the exposure. Formal instruction in science, let alone inquiry instruction is severely limited at this level where teachers are not specialized to teach science and thus they feel uncomfortable and even incompetent in teaching EAS (Lewin and Bajah, 1990). Laboratory facilities and other material requisites for inquiry instruction do not exist at the primary school level. Therefore taking into cognizance the fact that EAS is a recent innovation, it is conjectured that primary pupils in Zimbabwe do not have by any means, comparable exposure to activity-oriented science as Yager and Penick's elementary school children.

It is not clear why students who were least likely to have received exposure to formal instruction in science and let alone inquiry science instruction exhibited such highly favourable attitudes to science. If Mandebvu's (1991) assessment that students elected science and other subjects basing on their perceived value to the world of work is valid, it is not clear why F-4 students now most likely to enter the world of work exhibited marginal ATS. Science is often on of the required subjects in industrial and commercial vocations such as apprentice training.

While the five sub-scales on the ATSI represented and attempt to distinguish between composite aspects of the sample's ATS, no such distinction is statistically significant for G-7 and F-2 students perhaps reflecting the relative homogeneity of the students since intact classes were used. The F-2 and G-7 students in this sample can be described as having significantly positive ATS and their interest in science extends beyond the classroom. For example, they would want to be members of science clubs and show interest in a science career.

F-4 students reported significantly negative attitudes to three sub-scales depicting the "fun factor", the "practical investigator" and the "concrete scientist", a rather confusing result. First, it is always assumed that at all levels of the educational ladder a hands-on-practical-investigation approach would be more desired for favourable ATS to blossom. Second, it is not clear why they would rate more positively aspects that reflect a commitment to science, which supposedly should reflect that pupils find the subject valuable and worthwhile to pursue out of school in preference to other competing interests, and hence reflects a potential career aspiration (Egglestone et al., 1976). This inconsistency in ATS must be investigated.

Research on exemplary school science programmes suggests that students in these programs exit with positive ATS and that these students view their teachers as very influential in the development of these attitudes (Stefanich and Kelsey, 1989). Negative ATS reported for form four students must, until contrary evidence is found, cause science educators to take heed. These students represent the nation's prospective workers who are likely to enter the work-force with unfavourable feelings toward S & T in contradiction and disservice to national aspirations such as depicted in the FYNDP (1991-1995). In Harare region, for example, the instructional methods used to deliver science instructions are those methods not likely to support development of favourable ATS (Shumba, 1992b). It is necessary that colleges of education dissuade from presenting science to their pre-service and in-service teachers by convenient lecture methods (Chivore, 1986; Haeck, 1990). Such methods unlike the hands-on-investigation do not impart positive ATS in prospective teachers or the enthusiasm to make science enjoyable to others (Stefanick and Kelsey, 1989; Eichinger, 1992). Policy makers and resource providers should be made aware that science friendly attitudes are in the long term essential for national development and thus must take heed of material requests by colleges of education that would enable them to produce science teachers who are likely to regularly employ "dynamic and relevant instructional methods" with their pupils (Eichinger, 1992,609).

Responses to an open-ended item on their thoughts about science and scientists reflected that students at primary and the junior secondary school level might have an inadequate conception of science and scientists. For example, nearly all G-7 students viewed science and scientists as useful but described this in relation to medical nurses and doctors, typically in relation to immediate personal health experiences. This quote serves to corroborate this interpretation:

> I think science and scientists are useful, when I am sick with malaria the doctor and the nurses at the hospital make me well. Many people would die without nurses and doctors, I think science is a good thing. I want to be a doctor if I do well in school (Anonymous G-7 pupil, 1991).

F-2s tended to identify science and scientists with technological applications, electricity and machines. The F-4s (many of them female) tended to be concerned with negative aspects of S & T such as wars and weapons of mass destruction (perhaps reflecting a humane and societal concern on the misuses and abuses of S & T, and general anxiety induced by the recent high-tech Persian Gulf war). While findings on the perception of science and scientists is conjectural, a review of previous research and in their own study, Gogolin and Swartz (1992), observe that ATS are formed by both school and non-school variables which might work cumulatively to produce a distorted image of science and which must therefore be a subject of further investigation.

Implications for further research

The present study was based on a limited regional sample of students and hence an immediate concern should be replicate the study with a more representative national sample to include students in rural schools. I sampling, individual students rather than intact classes could give a more realistic picture of ATS. Further, the internal consistency reliability of the ATSI should be test. Open responses of students hint that students in the sample might have distorted or inadequate perceptions of science and science-related careers. A national study is therefore being planned by the author to examine more closely students' perceptions (and their origins) on the nature of science, technology, science classes, teachers and scientists.

While the curriculum has been illustrated to emphasize attitudinal outcomes substantially, current assessment practice fails to cover affective objectives. Since attitudes substantially influence career choices, amount of contact with that time devoted to a subject of study, and ATS are indicative of scientific literacy, applied studies which seek to shed light on ways to incorporate affective measures in national achievement assessment would be immediately desirable. The trend of ATS suggested by the findings presented here call for a longitudinal assessment of attitudes at various exit levels, and of the ATS of adults and workers so that a consistent awareness is maintained of the influence of pre-college S & T education and of the direction that influence should take. A substantial national budget should be made available for these regular assessments that would provide regular inputs to national efforts to become scientifically and technologically literate.

In the early part of Zimbabwe's independence (in 1984), by international standards, the bottom 20% of our junior certificate level students were ruled scientifically "literate" and the to 20% were consistently at the bottom of the 23 nations in and International Association for the Evaluation of Educational Achievement (IEA) assessment (Postlethwaite, 1991). While that survey did not include the affective dimension, in order to attain international competitiveness in S & T education, and indeed to hasten the pace of national social and economic development, a useful starting point is to raise the interest and awareness levels of all our students, and all our citizens, to science and technology!

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