BRUNEIAN EDUCATION STUDENTS' SCIENCE PROCESS SKILLS: IMPLICATIONS TO CURRICULUM AND MANAGEMENT

Reynaldo G. Segumpan
University Utara, Sintok, Malaysia

This descriptive-correlational study assessed the science process skills among the 100 final year pre-service teachers at the Sultan Hassanal Bolkiah Institute of Education, University Brunei Darussalam. Data were gathered using the researcher-made Science Inquiry Skills Test (SIST), Science Learning Attitude Scale (SLAS), Science Teaching Orientation Questionnaire (STOQ), through a non-structured interview, and data from university handbooks and records. Data were analysed utilising the SPSS software at 0.5 Cronbach alpha. Findings revealed that the performance of the subjects in the overall science process skills was "average." When categorised into basic and integrated skills, the subjects showed "average" basic science process skills and "poor" integrated science process skills. Significant relationships existed between the subjects' basic, integrated, and overall science process skills and (a) inquiry skills training hours, (b) science learning attitude, and (c) science content teaching orientation. Implications of the findings to curriculum and management are discussed.

INTRODUCTION

Science process skills, says Gega (1994) are the competencies that empower an individual to gather and reason about data to make better sense of his world. Alternatively known as science enquiry skills, these are the courses of action researchers use in scientific explorations, the mental mode of acquiring science concepts, and the didactic processes in lecture rooms (Millar, 1987). Few would argue that the transmission of accepted knowledge as the principal teaching mode and factual recall as the main means of assessment has traditionally dominated science education (Wellington, 1989). However, in the new science education curricula, the development of inquiry skills is now a highly sought goal in equipping teacher trainees with investigative or laboratory skills so that they adopt the spirit of inquiry and make learning a personal commitment. As Germann (1994) claims, through inquiry experiences, teachers help students not only to learn about science but also to think logically, ask reasonable questions, seek appropriate answers, and solve daily problems.

The science inquiry skills can be classified as basic skills and integrated or advanced skills. As a general rule, the basic science inquiry skills are more global, that is, they can be applied to most situations, whilst the integrated science inquiry skills apply more specifically to scientific investigation (Neuman, 1993). Understanding of these science processes is, therefore, implicit and essential so that science educators can properly guide their students in developing the skills required of scientific investigations.

In this study, the teacher education students' science process skills were assessed, grounded on the 12 science inquiry processes defined by Howe and Jones (1993). More specifically, answers to the following questions were sought:

1. What is the competency level of pre-service teachers in the following science inquiry skills?

Basic science process skills	**Integrated science process skills**
a. Observing	a. Inferring
b. Classifying	b. Predicting
c. Comparing	c. Formulating hypothesis
d. Measuring	d. Interpreting data
e. Quantifying	e. Controlling variables
f. Recognising/Using space/ time relation	f. Experimenting

2. Are there significant differences in the science inquiry skills of the subjects when they are grouped according to:
   (a) inquiry skill training hours (the total number of hours spent for laboratory/practical work across the whole teacher education programme);

(b) gender;

(c) attitude towards science learning (the degree of liking or favourableness or disliking or unfavourableness of pre-service teachers towards the learning of science);

(d) science process teaching orientation (the subjects' preconceived ideas regarding the extent of teaching of science through practical, laboratory, or investigative technique in the primary or secondary level); and

(e) science content teaching orientation (the subjects' preconceived ideas regarding the extent of teaching of science through lecture, tutorial, or teacher demonstration approach in the primary or secondary level)?

3. Are there significant relationships between science inquiry skills and (a) inquiry skill training hours, (b) gender, (c) attitude towards science learning, (d) science process teaching orientation, and (e) science content teaching orientation?

METHODOLOGY

This was a descriptive-correlational study utilising the 100 pre-service teachers who were in their final year at the Sultan Hassanal Bolkiah Institute of Education, University Brunei Darussalam (UBD) as the subjects of the study. As the sole university in Brunei Darussalam, UBD currently undertakes all science education responsibilities in the entire State.

Table 1 shows the distribution of the subjects according to gender and programme of study.

Table 1
Distribution of the Subjects by Gender and Programme of Study (N=100)

Category	**N**	**Percentage (%)**
Gender		
Male	24	24
Female	76	76
Programme of Study		
Certificate in Education	55	55
B.A. Primary Education	20	20
B.Sc. Education	25	25

In assessing the pre-service teachers' competency level in the science inquiry processes, the Science Inquiry Skills Test (SIST) was used. The SIST has 60 items, consisting of five items for each science inquiry skill, that is 30 items each for the basic and integrated skills. It has an overall Cronbach alpha reliability of 0.88. In ascertaining the attitude of the subjects towards science learning, the Science Learning Attitude Scale (SLAS) was utilised. The SLAS consists of 20 five-point Likert-type scale of positive-negative statements and has a reliability of .85. In determining the subjects' science teaching orientation, a 20-item Science Teaching Orientation Questionnaire (STOQ) was developed. Like the SLAS, the STOQ comprises 20 five-point Likert-type scale and has reliabilities of 0.83 for "process" items and 0.78 for "content" items. The research instruments were patterned after the research tools of a similar nature taken from available literature and based on the researcher's readings and experiences as a science educator. All the instruments were pilot-tested, modified, revised, and refined. In addition, a non-structured interview schedule was prepared to obtain information about science teacher education in the university from lecturers involved in the teacher education programmes. Those who participated willingly in the interview were asked to give their ideas, comments, and views on the laboratory/practical dimension of science education as well as share their experiences and practices on how they conduct their science classes.

Descriptive and inferential statistics using the SPSS for Windows software were utilised in analysing and interpreting the data at the 0.5 significance level.

FINDINGS

The Subjects' Level of Science Process Skills

Overall Science Process Skills

Table 2 summarises the mean scores of the pre-service teachers in all the science inquiry processes. The data show that the subjects have an overall competency level that can be described as "average" (Mean = 29.08; Max = 60). When categorised into basic and integrated skills, the subjects showed *average* (Mean = 17.82; Max = 30) competency level in the basic science process skills and *poor* (Mean = 11.30; Max = 30) competency level in the integrated science inquiry skills.

Table 2
The Subjects' Performance in the Science Process Skills

Science inquiry process	Mean	SD	Description	Rank
Observing*	3.31	1.04	Above average	1
Classifying*	2.43	1.15	Average	6
Comparing*	2.92	1.19	Average	4
Measuring*	3.24	1.30	Above average	2
Quantifying*	3.01	1.33	Above average	3
Recognising/Using Space Time Relation*	2.83	1.14	Average	5
Inferring**	2.09	1.37	Average	9
Predicting**	1.72	1.40	Poor	10
Formulating Hypothesis**	2.30	1.45	Average	7
Interpreting Data**	2.14	1.40	Average	8
Controlling Variables**	1.56	1.12	Poor	11
Experimenting**	1.43	1.08	Poor	12
Over-all sci. process skills	29.08	9.29	Average	
* Basic sci. process skills	17.82	5.19	Average	
** Integrated sci. process skills	11.30	5.13	Poor	

Key:

A. For each science inquiry skill	B. For each subset of basic/integrated science inquiry skills	C. For the over-all science inquiry skills	
Scale:	Scale:	Scale:	Description:
4.01 - 5.00	24.01 - 30.00	48.01 - 60	Excellent
3.01 - 4.00	18.01 - 24.00	36.01 - 48	Above ave.
2.01 - 3.00	12.01 - 18.00	24.01 - 36	Average
1.01 - 2.00	6.01 - 12.00	12.01 - 24	Poor
0 - 1.00	0 - 6.00	0 - 12	Very Poor

Basic Science Process Skills

Across the basic science inquiry skills, the subjects displayed *above average* performance in observing (Mean = 3.31), measuring (Mean = 3.24), and quantifying (Mean = 3.01) while they showed an *average* performance in comparing (Mean = 2.92), recognising/using space/time relation (Mean = 2.83), and classifying (Mean = 2.43). With respect to the integrated science inquiry skills, it was found that they had *average* competency level in formulating hypotheses (Mean = 2.30), interpreting data (Mean = 2.14), and inferring (Mean = 2.09) while their competency level in experimenting (Mean = 1.43), controlling variables (Mean = 1.56), and predicting (Mean = 1.72) was *poor.*

The relatively large standard deviation (9.29) in the subjects' overall mean scores indicates heterogeneity as regards to their performance in the SIST. This may be rationalised in terms of the diverse abilities of the subjects as well as the varying science courses provided in the different teacher education programmes in the University Brunei Darussalam. The subjects' school science background might have accounted also for this performance gap.

The findings of this study suggest that the subjects are relatively proficient in the overall basic science process skills, especially in observing, measuring, and quantifying where the subjects obtained a rating of above average. This performance could be attributed to, among other factors, the teaching-learning experiences provided in the teacher education curricula. For instance, it was established during the interview with the science lecturers involved in the teacher education programme that instructional activities like handling and using laboratory equipment and carrying out simple investigations have been provided to the student teachers. These activities are aimed not only at equipping them with the basic science inquiry skills but also at developing their manipulative or psychomotor skills.

Integrated Science Process Skills

With respect to the integrated science inquiry skills of the subjects, their performance in the SIST (Science Inquiry Skills Test) can be considered as poor (Mean = 11.30; Max = 30) with a large standard deviation (5.13) in their scores. This "poor" performance could be explained by the fact that these inquiry processes require a higher level of thinking and logical analysis and as such, are more difficult to master. Another plausible reason for this is the type of laboratory activities prevalent in university courses and the lack of training and opportunity for students to practise these skills. Most of the learning activities are that type where the students have to follow structured procedures and guidelines. They do not seem to have adequate exposure to independently performed laboratory activities and scientific experiments that require analytical and logical thinking. In other words, the students might have been exposed to the teacher-directed learning approach rather than the open-ended, discovery, and inquiry learning techniques, in addition to the varying and insufficient science background of the subjects when they were in the schools.

Differences in the subjects' Science Process Skills

The highest possible score for the basic and the integrated science process skills is 30 while it is 60 for the over-all science inquiry skills (sum of basic and integrated skills). Based on the data, it was found that the subjects' minimum and maximum scores for the basic science inquiry skills were six and 28 respectively, whilst for the integrated science inquiry skills, one and 21, correspondingly. The subjects obtained a minimum score of 12 and a maximum score of 48 in the over-all science inquiry skills.

In terms of basic science process skills, the data in Table 3 show that the subjects' competency level would differ significantly when they are grouped according to inquiry skills training hours ($F = 26.124$; $p = .000$), science learning attitude ($F = 27.977$; $p = .000$), and science content teaching orientation ($t = -2.852$; $p = .005$).

Table 3

Differences in the Subjects' Basic, Integrated, and Overall Science Process Skills According to Independent Variables (N = 100)

Independent variable	No of resp.	Science inquiry skills: Basic [B] Mean {SD}	Integrated [I] Mean {SD}	Over-all [O] Mean {SD}	F value	t value	2-tailed sig.
Inquiry skills training hrs							
High (140>)	39	21.44 {4.27}	14.67 {4.31}	36.00 {7.16}	26.124[B]	____	.000**
					20.524[I]	____	.000**
Moderate (112-139.99)	29	16.83 {4.17}	10.10 {4.51}	26.93 {7.71}	31.227[O]	____	.000**
Low (111.99>)	32	14.31 {4.22}	8.28 {4.24}	22.59 {7.15}			
Gender							
Male	24	18.04 {4.65}	12.46 {4.77}	30.42 {8.93}	____	.239[B]	.812
					____	1.272[I]	.206
Female	76	17.75 {5.37}	10.93 {5.22}	28.66 {9.42}	____	.807[O]	.422
Science learning attitude							
Positive (73.68>)	32	21.93 {3.69}	13.85 {4.25}	35.63 {6.00}	27.977[B]	____	.000***
					13.316[I]	____	.000***
Moderate (52.34-73.67)	26	20.44 {4.73}	14.31 {4.59}	34.75 {8.40}	25.278[O]	____	.000***
Negative (52.33<)	42	15.14 {4.22}	9.25 {4.74}	24.39 {8.04}			
Science process teaching orientation							
High (48>)	50	17.80 {5.23}	11.86 {4.85}	29.58 {9.26}	____	-.038[B]	.969
					____	1.092[I]	.277
Low (47<)	50	17.84 {5.19}	10.74 {5.39}	28.58 {9.39}	____	.536[O]	.593
Science content orientation							
High (20>)	56	16.55 {4.51}	10.54 {5.28}	27.09 {8.95}	____	-2.852[B]	.005**
					____	-1.696[I]	.093
Low (19<)	44	19.43 {5.58}	12.27 {4.82}	31.61 {9.20}	____	-2.479[O]	.015*

* Significant at .05 level of significance (p<.05)

** Significant at .01 level of significance (p<.01)

With respect to the integrated science process skills, the findings disclosed that significant differences would occur in the competency level of the subjects when they are grouped by inquiry skills training hours ($F = 20.524$; $p = .000$) and science learning attitude ($F = 13.316$; $p = .000$).

In the overall science process skills, significant differences in the subjects' competency level were observed when they were classified according to inquiry skills training hours ($F = 31.227$; $p = .000$), science learning attitude ($F = 25.278$; $p = .000$), and science content teaching orientation ($t = -2.479$; $p = .015$).

In order to identify which groups differed significantly, the Scheffe *post hoc* test was used. The findings revealed significant differences in the (a) basic, integrated, and over-all science inquiry skills and inquiry skill training hours, in favour of those having "high" exposure to inquiry skill training hours (140 hours and above) than those who had "moderate" (112-139.99 hours) and "less" exposure (111.99 and below); (b) basic, integrated, and over-all science inquiry skills and attitude towards science learning, in favour of those in the "high" and "moderate" categories than those in the "low" group; and (c) basic and over-all science inquiry skills and science content teaching orientation, in favour of those in the "low" group than in the "high" group. This explains the critical role of lecturers in providing the students adequate time for laboratory work and practical investigations. It may be said with confidence that when the pre-service students are given the experiences to explore and experiment on their own and to learn in an atmosphere where higher-order thinking skills and proper attitude are emphasised, they tend to be more critical about things and phenomena in their environment. Subsequently, they may imbibe a perspective of teaching science the "practical way," a classroom climate where students learn science through rational thinking and empirical investigations.

The differences in the number of inquiry skills training hours may be traced back to the programme type and science background of the subjects. Browsing through the information available in the faculty handbook on the subjects' programme type and science background, it was found that those in the Certificate in Education programme have only four "O" level credits (science included) whilst those in the B.A. Primary Education have two "A" level credits (science included); and those in the B.Sc. Education, at least two "A" level science credits.

The science background of the subjects in the university ranged from three to 64 course credits depending on the programme. Those in the Certificate in Education programme have a science background which ranges from three to six course credits; B.A. Primary Education, three to nine course credits; and, B.Sc. Education, 19 to 64 course credits. Hence, the science inputs (lectures, tutorials, laboratory work, among others) of the subjects also varied considerably. Student teachers in the B.Sc. Education programme would tend to be the most proficient in the science inquiry processes among the three groups studied, considering their science background and the number of inquiry skills training hours provided for them. Theoretically, students who are provided more time for laboratory and practical investigations should perform better in the over-all science inquiry skills than those whose involvement in such investigations is limited. The findings of this research seems consistent with the study done by Wade (1994) who found that students who are actively involved in their science learning experiences tend to develop better science process skills.

In terms of significant differences in science learning attitude, the findings suggest that those who had a relatively positive or favourable attitude towards learning science tend to have a better competency level in the science inquiry skills than those who have a negative or unfavourable attitude. It can be argued that students who like to learn science (positive attitude) will engage themselves more seriously and give in-depth attention during laboratory / practical investigations than those who perceive science as a difficult, tedious, or an unexciting course (negative attitude). As pointed out in the study by Brown (1994), students who had more positive attitudes towards science had a greater ability to identify and state hypotheses.

The significant differences in the science inquiry skills vis-á-vis science content orientation might be explained by the perception of student teachers that "hands-on, minds-on" activities in science (discovery approach) should be given more emphasis in science education rather than theories and concepts. Since the subjects had a low science content teaching orientation, it theoretically follows that they had relatively high preference for a process approach or inquiry-based instructional tasks during science lessons or investigations.

Relationships of Science Process Skills and the Independent Variables

As regards basic science process skills, Table 4 indicates that the subjects' basic science process skills are significantly and positively related to their inquiry skill training hours ($r = .647$; $p < .01$) and attitude towards science learning ($r = .585$; $p < .01$). The findings suggest that these variables have a direct and explicit influence on the basic science process skills of the subjects. On the other hand, science content teaching orientation was significantly yet negatively correlated ($r = -.237$; $p < .05$) to the subjects' basic science process skills. This negative relationship implies an inverse relationship between basic science process skills and science content teaching orientation; that is, as the subjects' scores in the basic science process test increase their orientation towards emphasising "content" (knowledge/theory-based) in the teaching of science decreases.

Table 4

Correlation Coefficients of Basic, Integrated, and Overall Science Process Skills with the Independent Variables

Independent variables	Basic skills	Integrated skills	Over-all skills
Inquiry skill training hours	.647**	.483**	.628**
Gender	.024	.127	.081
Attitude towards science learning	.585**	.386**	.532**
Science process teaching orientation	.107	.157	.143
Science content teaching orientation	-.237*	-.202*	-.236*

* p<.05 ** p< .01

However, gender and science process teaching orientation did not yield significant results, as evidenced by Eta = .024 and $r = .107$, respectively. This suggests that competency level in the basic science process skills is not significantly influenced by these variables.

Interestingly, the same variables were significantly and positively correlated with the subjects' integrated science process skills: inquiry skill training hours ($r = .483$; $p = < .01$) and attitude towards science learning

($r = .386$; $p < .01$). Although these variables yielded moderately high correlation coefficients, the obtained probability values were statistically significant at the 0.01 level of significance. The correlation coefficients, generated in the preceding analyses, however, were higher than those yielded here. This implies that these variables (inquiry skills training hours and science learning attitude) exerted a stronger influence on the subjects' basic science process skills than the integrated science process skills.

Moreover, the subjects' integrated inquiry competency level was significantly yet negatively correlated ($r = -.202$; $p = < .05$) to their science content teaching orientation, as in the case of basic inquiry skills. This seems to support the notion that student teachers who are deficient in the integrated science inquiry processes would prefer theory-based teaching/ learning to emphasise "content" in science teaching than "process" (laboratory-based). This assumption parallels an earlier finding that inquiry instruction in science was perceived by some science teachers to be time-consuming, appropriate only for clever students, difficult to organise, and created discipline problems.

Furthermore, the findings revealed that gender and science process teaching orientation are not significantly related to the subjects' integrated science inquiry skills, as evidenced by the Eta and the r coefficients of .127 and .157, respectively.

On the whole, the pre-service teachers' science inquiry skills were found to be statistically and positively correlated to the independent variables mentioned in the foregoing paragraphs - inquiry skill training hours ($r = .628$; $p < .01$) and attitude towards science learning ($r = .532$; $p < .01$). These variables were therefore thought of as having a very strong bearing on the competency level of the subjects both in the basic and the integrated science process skills. Similarly, a significant yet negative relationship was noted between over-all science process skills and science content teaching orientation ($r = -.236$; $p < .05$).

Some findings in this study are consistent with the significant results of two previous studies which disclosed that over-all science process skills were related to attitude towards science and science-related training. How the subjects' competency level in the over-all science inquiry skills was significantly influenced in this study by their inquiry skill training hours could be explained by the nature of the teacher education curricula of the subjects. Those in the B.Sc. Education programme are provided with numerous science courses (19 to 64 units) while those in the B.A. Primary and in the Certificate in Education programmes have only a few science courses (between 3 and 9 units). It is most likely that those having more science background will also have more exposure to inquiry skill training and hence develop better over-all science process skills.

Furthermore, the statistical analyses revealed that gender and science process teaching orientation had no significant relationship with science inquiry skills. This finding does not support the finding that gender was significantly associated with science process skills, as identified in the research of Davo (1982) and Peters and Haley (1980).

IMPLICATIONS, CONCLUSIONS AND RECOMMENDATIONS

One evident implication of the findings concerns the competency level in the integrated science process skills of the pre-service teachers, which was identified to be "poor". Efforts should be made to provide more and varied opportunities for the students to design and conduct experiments, control variables, and predict events that might occur in a scientific investigation, as well as to make logical hypotheses, inferences, and interpretation of data. Since the integrated or advanced science inquiry skills are substantially dependent on knowledge of more complex experimental procedures and on reflective understanding of the scientific concepts, care would have to be taken in selecting investigations appropriate to the students' knowledge and skills. As suggested in the Assessment of Performance Unit (APU) Report (1982:175):

> It is likely that low levels of performance in some areas are due to lack of exposure of students to the types of tasks involved; additional attention in these areas may significantly affect levels of performance. In other areas, however, low levels of performance may be a reflection not of lack of emphasis in teaching but of the difficulty or complexity of the types of tasks themselves.

The lecturers involved in the teaching of science in UBD have been trying their best to develop the students' science inquiry skills. In fact, the pre-service teachers' performance in the basic science inquiry skills were found to range from average to above average. This indicates that the development of these basic skills might have been given considerable emphasis in science education. However, acquiring mastery in the basic science process skills is not enough to enable prospective teachers to impart knowledge and skills to their pupils efficiently and effectively at the secondary level. An acceptable competency level of the integrated science inquiry processes is necessary and indeed is a must. It is implied, therefore, that the science educators involved in the teacher education of the pre-service teachers should initiate modest efforts to review the kind and type of laboratory activities or practical work provided for. The activities they have been conducting might be quite difficult, if not complicated, for the students to comprehend, fully understand, and apply in real-life situations. As stressed in the aforementioned APU Report: "Science teaching should give students more opportunities to apply their knowledge of the science inquiry process skills in order to achieve mastery over it" (p. 175). Whether the discrepancies are in the type of activities undertaken or in the level of difficulty of the tasks given or otherwise, science educators and policy-makers shall collaboratively explore on plausible measures and strategies that would alleviate the level of competency in the integrated or advanced science inquiry skills of the pre-service teachers. It is suffice to say, the pre-service teachers' basic science process skills should also be evenly attended to.

The large disparity in the inquiry skill training hours across the three teacher education programmes studied had a significant influence on the pre-service teachers' science inquiry skills. This dissimilarity might have created a wide gap in exposure to laboratory experiences and practical work and investigations which might influence the pre-service teachers' science inquiry skills, and consequently, their views or impressions of science learning and teaching. If the subjects had not accumulated substantial hours for inquiry skill training and development, they might be unable to teach science with confidence, especially to emphasise the science inquiry skills in their lessons and other instructional activities. Most likely, if the basic science inquiry skills are not strengthened and the integrated science inquiry skills are not enhanced, the quality of science instruction in the primary and secondary schools might be adversely affected. The implication of these observations is clearly stated by Lourdusamy and Hassan Hamid Tairab (1997:28).

> Science teachers should contribute to narrowing the gap between classroom science and its application to daily life by emphasising the contributions that laboratory activities could make in raising the learners' various intellectual and procedural skills that are likely to be useful to students' future careers.

Furthermore, the findings in this study disclosed that trainees who have more science knowledge and exposure to manipulative/investigative activities that dealt with the development of science inquiry skills performed well in the Science Inquiry Skills Test (SIST). This gains support from Germann (1994) who underscored that students who have sufficient scientific knowledge find learning science process skills easier. If more desirable levels of students' science inquiry skills are expected, extensive "content" and "process" opportunities and experiences should be accorded to student teachers. Through this, they would be able to demonstrate competence in both the theoretical and the practical aspects of science learning and teaching and apply in other unfamiliar situations, the knowledge learned and skills developed.

When students received additional supervision and were taught in an encouraging and reassuring environment, they were able to overcome entry level deficiencies (Cain, 1994). Adapted to the present study, Cain's statement would support the implication of the need for more science courses and increased inquiry skill training hours in the teacher education curricula of the Certificate in Education and B.A. Primary Education programmes. This is to enable the students to be proficient and adept in the science inquiry processes. Promotion of a satisfying, wholesome science classroom environment needs also to be maintained.

Moreover, it is recommended that additional science courses and inquiry skills training hours be added in the Certificate in Education and the B.A. Primary Education. Apparently, the B.Sc. Education curriculum has adequate science courses and inquiry skills training hours, as evidenced by their above average rating in the over-all science inquiry skills. It is understood that those in the Certificate in Education and in the B.A. Primary Education programmes are trained to be primary teachers. Since these student teachers are expected to be general purpose teachers in primary schools, they have more challenging roles in imparting to their pupils scientific knowledge, skills, and attitudes that need to be developed at their young age so that these pupils advance their creativity and problem-solving abilities. The basic science inquiry skills of those with low average mean scores should be strengthened because the science curriculum in the primary grades puts high emphasis on the development of basic science inquiry skills. In view of this, proper understanding of the basic science inquiry processes should be given more emphasis among the students in the said programmes. As regards those in the B.Sc. Education programme, the development of the integrated or advanced science inquiry processes should be given more attention as the student teachers in this programme will be science teachers in secondary schools. In general, student teachers should be encouraged and given the chance to develop their basic and integrated science inquiry skills and positive science learning attitudes in an authentic inquiry-oriented learning environment that moves away from simple replication of scientific knowledge (Coulter, 1996).

Attempts should be made to change a number of the pre-service teachers' negative or unfavourable attitudes towards science learning. Science educators involved in the teacher education programme should exert more efforts in identifying and utilising some teaching and laboratory techniques that would not only optimise science achievement but also science learning attitudes. As underscored by Germann (1994), students with a favourable attitude towards science will find learning process skills easier than those who have unfavourable attitudes. This is a highly challenging task for the science educators, but as Hewson, Kerby, and Cook (1995) posited, pre-service teachers do not have various ideas and conceptions about science learning which can be changed as an outcome of teacher education programmes. Through the lecturers' constant motivation and encouragement during the teaching-learning activities in science, the students can reconceptualise their perceptions about science learning so that they will be more involved in the activities. Innovative and creative instructional styles, such as peer collaboration, among others, may also aid in facilitating a fun-filled and enjoyable science environment. School and university students should be convinced that science is exciting and fascinating and not only for smart or intelligent students. It is only when students feel that studying science is worthwhile and gratifying that a positive and wholesome attitude towards learning science is assured.

In a nutshell, policy makers, curriculum developers, and science educators in the university and other teacher education institutions should look into the variables that contributed to the variance in the science inquiry skills and institute some measures that would effect improvement in the students' science inquiry skills. If these people want to increase student competence in the science inquiry processes, improvement in planning and instructional practices should be carried out (Strawitz and Malone, 1987). A detailed examination of the types of inquiry training activities and the development of science-related activities is also suggested.

For future research, other factors not included in this study which might correlate with science inquiry skills such as students' science entry level qualifications and study habits, lecturers' competence and attitude, among others, should be explored. Experimental and exploratory researches on the development of students' science inquiry skills in science content-oriented and in process-oriented courses or curricula is also an interesting endeavour. In addition, the science inquiry processes, especially the integrated or advanced ones, should be given significant attention in instruction during practical investigations. Finally, a re-examination and further analysis of the reliability and validity of the research tools are recommended to establish wider applicability, especially across cultures.

REFERENCES

Assessment of Performance Unit (1981 & 1982). *Science in Schools: Report No.1*. London.

Brown, F. S. (1994). An assessment of the effects of inquiry instruction on undergraduate biology students' understanding of biological concepts and attitudes about science. Ph.D. dissertation, Miami University. *Dissertation Abstract International-A, 55* (11), 3465.

Cain, P. S. (1994). A comparative study of the effect of entry level skills of pre-service teachers on their passage through teacher development stages. *Dissertation Abstract International-A, 56* (09), 3546.

Coulter, R. W. (1996). An analysis of computer-mediated learning in elementary school science. Ed.D. dissertation, Boston University. *Dissertation Abstract International-A, 57* (03), 994.

Davo, L. P. (1982). Science process skills of entering first year high school students of Iloilo State College of Fisheries. Unpublished Master's thesis, West Visayas State University, Iloilo City, Philippines.

Gega, P. C. (1994). *Science in elementary education.* New York: Macmillan.

Germann, P. J. (1994). Testing a model of science process skills acquisition: An interaction with parents' education, preferred language, gender, science attitude, cognitive development, academic ability, and biology knowledge. *Journal of Research in Science Teaching, 31* (7), 749-783.

Hewson, P. W. Kerby, H. W., & Cook, P. A. (1995). Determining the conceptions of teaching science held by experienced high school science teachers. *Journal of Research in Science Teaching, 32* (5), 503-520.

Howe, A. C. & Jones, L. (1993). *Engaging children in science.* New York: Macmillan.

Lourdusamy, A. & Hassan Hamid Tairab (1997). Views of teachers and student teachers on the role of practical work in school science. *Journal of Applied Research in Education, 2,* 23-30.

Millar, R. (1987). What's 'scientific method' and can it be taught? In Wellington, J. (Ed.) (1989). *Skills and Processes in Science Education* (pp. 47-62). London & New York: Routledge.

Neuman, D. B. (1993). *Experiencing elementary science.* California: Wadsworth.

Peters, A. M. & Haley, D. (1980). Identifying factors related to science process skill of performance levels. *School Science and Mathematics, 80,* 273-276.

Strawitz, B. M. & Malone, M. R. (1987). Preservice teachers' acquisition and retention of integrated science process skills: A comparison of teacher-directed and self-instructional strategies. *Journal of Research in Science Teaching, 24* (1), 61-75.

Wade, W. J. (1994). The effects of traditional instruction, laboratory experiences, and computer-assisted instruction on ninth-grade biology students' science process skills achievement. Ed.D. dissertation, Delta State University. *Dissertation Abstract International-A, 56* (03), 816.

Wellington, J. (1989). *Skills and processes in science education* (Ed.). London & New York: Routledge.

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