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CORRELATES OF CONCEPTUAL KNOWLEDGE OF SCIENCE PROCESSES WITH SOME DEMOGRAPHIC VARIABLES OF UNDERGRADUATE STUDENTS: THE CASE OF UNIVERSITY OF BOTSWANA

Hezekiah Ukegbu Emereole

Abstract. *The conceptual knowledge of the science process of University of Botswana science students was sought through a questionnaire. Copies of the questionnaire were administered during briefing laboratory sessions in which the students had no practical lab work to do. The expressed conceptual knowledge was scored using a validated list of definitions of science processes. The analysis revealed that there was no correlation between the students' conceptual knowledge of the processes and their demographic variables of gender, age, present programme of study, year of study, desired profession, secondary school science programme followed, their school and home environments. Their ability to provide correct conceptual definitions did not corroborate their stated level of familiarity with the science processes. No student gave correct definitions for three of the science processes, only 3% and less could give correct definitions for 10 of the 15 processes, and only for the processes of classification and communication were the percentages of correct definitions up to 23.3% and 8.2% respectively. It was suggested that science educators at all levels should ensure that their students acquire both conceptual and practical knowledge of the science processes.*
Key words: *undergraduate students' conceptual knowledge of science processes.*

Hezekiah Ukegbu Emereole
University of Botswana,
Gaborone, Botswana

Introduction

Recently, science teachers in Botswana expressed concern over the state of the acquisition of science process skills in the schools. This came in the wake of curricular demands for continuous assessment which for science is mainly the assessment of practical work (Ministry of Education of the Republic of Botswana with University of Cambridge Local Examinations Syndicate, undated). In Botswana, the objective of acquiring science process skills or investigation and experimental skills is stated in the junior and senior secondary school science syllabuses. The science processes specifically required at the junior secondary school level are observing, classifying, measuring, communicating, inferring, predicting, formulating hypothesis, experimenting, interpreting data, and controlling variables (Republic of Botswana, 1991). Others not specifically mentioned are counting numbers, raising questions, formulating models, making operational definitions, and manipulation. It is assumed that the exposure at secondary school should prepare students sufficiently to pursue science programmes at tertiary level. Thus at the tertiary level students are supposed to just apply the science processes they had already learned. Therefore this study was to survey and ascertain tertiary science students' conception of the science processes they were expected to use.

In course of my teaching the Year 3 B Ed Science Education students at the University of Botswana it became apparent that they could not explain what was meant by controlling variables. They could not also explain many of the other processes clearly. At the tertiary level, science students still do a lot of cookbook experiments. It is usually in their final years that they do projects that may really expose them to "doing science." It was, therefore,

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the intention in this study to determine the conceptual development of science process knowledge among tertiary students in science and science-related programmes in the university. More specifically, answers were sought for the following research questions:

- i) Do tertiary science students' conceptions of science processes corroborate their stated familiarity of the same?
- ii) Do tertiary science students' conceptions of science processes depend on their years of exposure to science learning?
- iii) Do tertiary science students' conceptions of science processes depend on their gender?
- iv) Do tertiary science students' conceptions of science processes depend on their age?
- v) Do tertiary science students' conceptions of science processes depend on their specific programme of study?
- vi) Do tertiary science students' conceptions of science processes depend on their proposed career aspirations?
- vii) Do tertiary science students' conceptions of science processes depend on the environment of the secondary schools they attended?
- viii) Do tertiary science students' conceptions of science processes depend on the environment in which they grew up?

Theoretical Framework

The premise of this study was underpinned by two theoretical understandings:

1. Science practical work constitutes a domain of knowledge. This framework is similar to Campbell, et al's (2005:5) framework that the scientific approach to enquiry is a domain of knowledge.
2. Undergraduate science practical work should improve students' conception of science processes.

As a domain of knowledge, practical work usually gets learned where the practitioners work. Farming is learned in the farm, mechanic work is learned in the mechanic shed, tailoring is learned in the tailor's shed, etc. It is not different for science. Hence a commonly quoted reference for practical work in science is Solomon's (1980:13) statement that science teaching must take place in the laboratory as science simply belongs there as naturally as cooking belongs to the kitchen. There is therefore a general acceptance of the view that the science processes usually employed by scientists have to be acquired in the laboratory. However each science process has a theoretical or conceptual part as well as an operational or practical part.

Many researchers have investigated the value of practical work in schools (Beatty & Woolnough, 1982; Gayford, 1988; Gould, 1978; and Kerr, 1963). The popular claims for practical work as summarized by Harlen (1999:7) are:

> That it served to motivate, to teach skills, to enhance conceptual learning, to give insight into the scientific method, and to develop scientific attitude such as open-mindedness, objectivity and willingness to suspend judgement.

However, Hodson (1993) did not find much convincing evidence in support of these claims. Furthermore, Hofstein & Lunetta (1982) pointed out that apart from poor facilities, the following are some of the factors that militate against effective practical work in schools:

> Few teachers in secondary schools are competent to use the laboratory effectively…
> Too much emphasis on laboratory activities leads to a narrow conception of science…
> Too many experiments performed in school are trivial…
> Laboratory work in schools is often… unrelated to the capabilities and interests of the children (Quoted by Harlen, 1999:7).

Pandilla (1990:1) reported that science process skills were popularized by the curriculum project, Science – A Process Approach (SAPA) and were defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behaviour of scientists. Of particular interest in this study was the conceptual understanding of the science processes themselves.

According to Allie, et al, (1998), students' understanding of a variety of physics concepts have been reported for students at different levels; on the other hand, the procedural understanding of science students is rarely studied nor used as a starting point for teaching. By procedural understanding or 'procedural knowledge' (Millar, et al, 1994) they mean what some refer to as 'declarative knowledge' (e.g. Black, 1993), that is, understanding about science concepts, phenomena and laws. Campbell, et al (2005) concluded that their studies on tertiary entry physics students' ideas about measurement "indicate that the point and set paradigms are useful theoretical constructs underlying a range of measurement actions at different stages of experimentation, …" (p.79) The studies did not however reveal whether students had a broad conceptual understanding of what measurement meant.

Sere, et al (1993) reported that some French physics students who were proficient in applying certain algorithms, such as calculating means, standard deviations and confidence intervals with their measurement data, showed little understanding of the underlying concepts. This could be because such algorithms might just be provided as formulae without effective discussion of the concepts.

Tomlinson, et al (2001) suggested that students should be required to use a set of well-defined key words in their practical report. Such well-defined key words would have a conceptual part and a practical part. The conceptual part would be procedural knowledge and relate to what some modern cognitive psychologists refer to as cognitive objectives of instruction (Lesh & Clarke, 2000). Reynolds (1991) reported that an experimental-based physical science programme in the US found no cognitive effect on grades 4 to 8 students. There would be no such effect if the cognitive objective was not seen as important, and students might end up not understanding why they did the practical. This type of practical could be regarded as rote practical work. Conceptual understanding and appropriate use of technical vocabulary should be important science objectives, but certainly not memorization of technical vocabulary.

Usually science students in tertiary institutions continue to do practical work in their programmes. It is not clear whether they have proper conceptual understanding of the science processes they practise. The conceptual part would relate to the underlying constructs of the processes which have been elaborated by the conceptual definitions provided by the educators mentioned in the next section. This study was to determine the correlates of conceptual knowledge of science processes possessed by undergraduate students, and whether exposure to tertiary science programmes at the University of Botswana had any effect on this knowledge.

Methodology of Research

This study began by the author condensing the conceptual definitions and meanings of science process skills provided by Pandilla (1990), Gbamanja (1991, pp.122-133), Standards Department of the Ministry of Education of the Province of British Columbia (1999), Valentino (2000), and National Science Teachers Association's (2004) write-up on Professional Reference for Teachers on Process skills. This was in order to provide acceptable meanings or definitions of the processes. After validation through expert judgement by science education lecturers in the university, these condensed meanings were taken to be standard. The final version of the definitions is in the appendix.

The study adopted a simple survey approach that employed a three-part questionnaire for data collection. The first part solicited subjects' demographic data; the second part required them to select from the options of *not familiar, uncertain,* and *very familiar* in order to express their familiarity with each science process; the third part requested them to provide their conceptions or definitions of each science process. The questionnaire was piloted with a small number of B Ed (Science) students.

The population for the study were students of science and science-related programmes in the University of Botswana. The sample consisted of entering students to Final Year science and science

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education students who took physics as their major or minor subject. Entering students were secondary school graduates just admitted to the university.

Copies of the questionnaire were administered on Year 1, 2, 3 & 4 students during their first physics laboratory briefing sessions in the second semester when they had no practical work to do; they had ample time to complete the questionnaire. Copies were also administered on entering students during their first laboratory briefing sessions in the next academic year. In all the cases, completed copies of the questionnaire were collected immediately on the spot.

The assessment of the subjects' responses was done by the author alone in order to avoid the complications of inter-rater reliability. It focused on the extent the subjects' ideas were correct or acceptable and not whether the exact words were used. However, one of the science educators that validated the instruments also helped to check the consistency of the scoring before the data were analysed. This educator was of the opinion that very good consistency was reflected in the scoring of the responses. The scoring was on the ordinal scale of 0 for incorrect, 1 for partially correct, and 2 for correct definitions.

Results of Research

The analysis involved assessing the subjects' conceptions or definitions of each science process and scoring them in a coded form as incorrect, partially correct or correct, based on their congruence with the standard definitions. These scores were then correlated with the demographic data of the subjects.

Claims of familiarity and actual definitions

Table 1 presents the students' claims to levels of familiarity with the science processes. A glance at the column of 'very familiar' shows that less than 50% of the students claimed familiarity with 8 processes and over 50% claimed familiarity with the remaining 7 processes. Put in another way, there were 8 out of 15 processes that majority of tertiary science students could not claim familiarity. This list included inferring, raising questions, formulating hypothesis, making operational definitions, formulating models, predicting, controlling variables, and manipulation. It is obviously a matter of serious concern that more that 50% of tertiary science students could not conceptualise these science processes.

Table 1. Percentages of students Claiming Familiarity with the Processes.

	Not familiar	Uncertain	Very familiar	Not indicated
Observation	1.1	18.7	79.4	0.8
Classification	4.9	38.1	54.0	3.0
Counting numbers	2.8	6.2	90.0	1.0
Measurement	0.9	10.4	86.3	2.4
Inferring	33.8	44.2	16.2	5.6
Communication	4.7	29.8	63.4	2.1
Raising questions	12.4	36.4	49.0	2.1
Formulating hypothesis	13.3	47.4	36.7	2.5
Experimenting	3.5	22.2	72.7	1.6
Making operational definitions	23.9	50.6	21.8	3.7
Formulating models	31.6	43.9	20.9	3.5
Interpreting data	5.0	30.2	63.6	1.2
Predicting	11.7	39.2	46.9	2.1
Controlling variables	21.9	41.5	33.8	2.7
Manipulation	30.6	38.3	29.8	1.2

Table 2 presents the percentages of subjects' who stated their conceptions of the science processes. The first thing one noticed in the table was the fact that the total number of subjects who gave their conceptions of the processes was very low compared to the number of subjects who indicated their levels of familiarity with the processes. Those who gave their conceptions were about 17.4% of those who indicated their levels of familiarity. Of this 17.4%, not all gave their conceptions to all the science processes.

Table 2. Percentages of students providing definitions for the processes.

	Incorrect	Partially Correct	Correct	Not indicated
Observation	82.5	12.8	1.2	3.5
Classification	40.7	30.8	23.3	5.2
Counting numbers	74.3	6.4	0	19.3
Measurement	62.4	21.4	2.3	13.9
Inferring	61.7	6.2	1.9	30.2
Communication	48.1	37.3	8.2	6.3
Raising questions	50.3	36.6	3.1	9.9
Formulating hypothesis	69.8	15.4	0	14.8
Experimenting	70.1	20.7	0.6	8.5
Making operational definitions	66.1	3.6	0	30.3
Formulating models	61.3	16.1	1.8	20.8
Interpreting data	58.3	32.6	1.1	8.0
Predicting	59.5	30.1	2.9	7.5
Controlling variables	61.8	12.7	2.9	22.5
Manipulation	77.3	1.7	0.6	20.5

A glance at the column of 'correct' in Table 2 reveals that the students' claims of familiarity with the processes could not be substantiated by their ability to propose acceptable, articulate, conceptual definitions of the processes. It was only with the processes of classification and communication that less than 50% of the students gave incorrect definitions. Well over 50% gave incorrect conceptions for the other 13 processes. The percentages of respondents who gave correct definitions for classification and communication were 23.3 and 8.2 respectively; those who gave partially correct definitions were 30.8% and 37.3% respectively. Apart from these two processes, the percentages of respondents that gave correct definitions were not more than 3 for the science processes.

No subjects gave correct definitions for counting numbers, formulating hypothesis and making operational definitions. Only 0.6% of the respondents gave correct definitions for experimentation and manipulation. If correct and partially correct definitions were combined, only classification and communication had above 45% but not more than 54% of respondents giving acceptable definitions; for all other processes, those who gave correct and partially correct definitions were less than 40%. It was surprising that observation had the highest percentage of incorrect definitions.

The percentages of students who gave correct conceptual definitions of the science processes were generally very low, not more than 3% except for classification and communication. Therefore these percentages for correct definitions were not used for further analysis in this paper. Also, the numbers of those aged below 18, those aged above 23, and those who were doing some other science related programmes were very few (10 and below); so they were also not included in these analyses since their percentages could create some false impression.

Groups within demographic factors were compared to find out if and how their conceptions of the processes were influenced by the factors. Table 3 presents a summary of this comparison in terms of the percentages that gave no correct definitions and the combined percentages of those who gave correct and partially correct definitions. This table reflects the actual sample sizes that responded. The bold figures in the table could be interpreted as being the better or best sub-group within the factor.

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Correlating definitions with Gender

Each gender gave no correct definitions for 4 processes out of 15 processes. Females were better in 10 processes and males were better in 5 processes based on the combination of percentages that gave correct and partially correct conceptual definitions. Since the scores for the conceptual definitions of the science processes were ordinal scores, and gender is dichotomous, nonparametric analyses were done using Mann-Whitney U for the gender factor. This showed that females were significantly better in their conception of classification and inferring, while males were significantly better in predicting.

Table 3. Sub-groups with no correct and those better in giving correct definitions.

Demographic Factors	Composition (Numbers and %)	No correct definitions in x number of processes	Better than others in y number of processes
Gender	257		
Females	68 (26.5)	4	10
Males	189 (73.5)	4	5
Age	242		
18-20	216 (89.3)	4	6
21-23	19 (7.9%)	9	9
Present Programme of study	255		
B. Ed (Science)	18 (7.1)	11	8
B. Sc.	237 (92.9)	4	7
Year of study	296		
Entering Students	158 (53.4)	6	3
Year 1	68 (22.9)	8	7
Year 2	25 (8.4)	10	5
Professions Desired	255		
Engineering	78 (30.6)	10	2
Medicine	74 (29.0)	6	7
Pure Science	42 (16.5)	7	1
Information/Computers	22 (8.6)	12	5
Secondary School Programme	253		
Double Award Science	30 (11.9)	12	1
Separate Sciences	223 (88.1)	4	14
School Environment	257		
Urban	113 (44.0)	4	7
Semi-urban	77 (30.0)	5	3
Rural	67 (26.1)	8	5
Home Environment	253		
Urban	82 (32.4)	6	6
Semi-urban	87 (34.4)	8	5
Rural	84 (33.2)	6	4

Correlating definitions with age of respondents

Those aged 18-20 and 21-23 gave no correct definitions for 4 and 9 processes respectively. Those aged 18-20 and 21-23 were better than the rest in 6 and 9 processes respectively based on the combination of percentages of respondents that gave correct and partially correct conceptual definitions. Spearman correlation did not show any significant difference between the mean conception scores of different age brackets.

Correlating definitions with programmes of study

Bachelor of Education (Science) students and Bachelor of Science students gave no correct definitions for 11 and 4 processes respectively. B Ed. (Science) students and B.Sc. students were better than others in 8 and 7 processes respectively based on the combination of percentages of respondents that gave correct and partially correct conceptual definitions. Kruskal-Wallis test showed no significant difference between the mean conception scores of the programme groups.

Correlating definitions and Year of Study

Entering students, Year 1, and Year 2 students gave no correct definitions for 6, 8, and 10 processes respectively. Entering students, Year 1, and Year 2 students were better than the others in 3, 7, and 5 processes respectively based on the combined percentages of respondents that gave correct and partially correct conceptual definitions. Spearman correlation showed that Year 1 students were better than the rest in their conception of measurement, interpreting data and predicting, and Year 2 students were better in their conception of formulating hypothesis.

Correlating Definitions with professions desired

Students who desired careers in information and computer science, engineering, science, and medicine gave no correct definitions in 12, 10, 7, and 6 processes respectively. Aspirants for information and computer science, engineering, science, and medicine were better than others in 5, 2, 1, and 7 processes respectively based on the combination of percentages of subjects that gave correct and partially correct conceptual definitions. Kruskal - Wallis test showed no significant difference between the mean conception scores of aspirants of different professions.

Correlating Definitions with secondary school science programme followed

Students who did separate sciences (i.e. biology, chemistry and physics) and those who did other combinations (like double award science, combined science, etc.) in secondary schools gave no correct definitions in 4 and 12 processes respectively. Students who did separate sciences and those who did other science combinations were better than the rest in 14 and 1 process respectively if the percentages of those who gave correct and partially correct conceptual definitions were combined. Spearman correlation showed that those who did separate sciences were significantly better than the rest in their conceptions of raising questions and formulating hypothesis, while those who did double award science were significantly better in their conceptions of predicting.

Correlating Definitions with secondary school environment

Students who attended senior secondary schools in urban, semi-urban and rural environments gave no correct definitions in 4, 5, and 8 processes respectively. Students who schooled in urban, semi-urban and rural secondary schools were better than the rest in 7, 3, and 5 processes respectively if the percentages of those who gave correct and partially correct conceptual definitions were combined. No significant differences were shown by Spearman correlation.

Correlating Definitions with home environment

Students who grew up and lived in urban, semi-urban and rural environments gave no correct definitions in 6, 8, and 6 processes respectively. Students who lived in urban, semi-urban and rural areas were better than the rest in 6, 5, and 4 processes respectively if the percentages of those who gave correct and partially correct conceptual definitions were combined. No significant differences were shown by Spearman correlation.

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The above analysis seemed to suggest that with regard to having conceptual knowledge of science processes:

i) Female students were better than male students;
ii) Students aged 21-23 were better than those aged 18-20;
iii) B.Sc. and B Ed (Science) students were at par;
iv) Year 1 students could be better than the rest;
v) Aspirants for medicine were better than students aspiring for other careers;
vi) Students who did separate sciences in secondary schools were better than the rest;
vii) Students who lived and schooled in urban areas were better than others.

Discussion

Poor conceptual knowledge of science processes

Practical work is seen as a necessary aspect of science teaching and learning. The poor conceptual knowledge shown by students in this study seemed to confirm the view that many science teachers are not competent to handle science practical work effectively (Hofstein & Lunetta, 1982). This does not appear to be a few isolated cases within Botswana. The sample comprised a large number of science students in the only university that admits students for science and science related careers in Botswana. The students in the study hailed from different parts of the country and could be considered to be very representative of Botswana undergraduate science students.

The findings that under every demographic factor, the percentages of subjects that gave incorrect definitions were very high (above 50%) and the percentages that gave correct definitions very low (about 3% and lower) have serious implications for the future of science learning and teaching in Botswana. It is like the type of sandy foundation laid by teaching measurement without the history of what the original problem was that led to standardizations. Without it, people would be doing rote practical work in schools and not be able to describe what they were doing and why they were doing it.

There is something basically wrong with an undergraduate science student being able to perform some processes without having an articulate, conceptual knowledge of it. It may not be the case that this ignorance exists only in Botswana. It definitely requires further investigation of how practical work is taught in science classes in different parts of the world.

The case for classification and communication

It is not clear why 23.3% and 8.2% of subjects gave correct definitions for classification and communication respectively and less than 3% gave correct definitions for the other science processes. It may be because these terms are used often in common language and there is no real difference in meaning between common language and science meaning of the terms. This is not quite the case with many of the other processes. For instance, whereas observation in common language may refer to the use of sight, its use in science extends to all the five senses and their man-made extensions. Some see manipulation in common language as having the ability to outwit somebody or getting away with certain behaviours, like "cooking experimental results," as some subjects actually wrote. For this purpose, science teachers ought to stress the distinction between science language and common language usage of science terms.

The cases of no correct conceptual definition

No one gave any acceptable conceptual definitions for counting numbers, formulating hypothesis and making operational definitions. Many considered counting numbers to mean knowing and using the natural numbers or the positive integers. That is the way any scientifically uninformed mind would think of it, not knowing that scientifically it goes beyond that. Besides, except there is a definite effort to teach and learn such a concept, people simply assume that they know what is meant by counting numbers since they have been counting from childhood.

Many thought that formulating hypothesis was just making a wise guess; they did not state that the guess would be about solutions to problems, answers to questions and relationships between variables, and that the statement would still need verification. The idea of formulating hypothesis is very common in science classes. This would definitely be the case of thinking that something is talked about so much that it is assumed known. Poor conceptual knowledge of this particular process actually shows that no efforts are made to consider the conceptual knowledge of science processes.

Making operational definitions appeared to be totally strange to the subjects; it is not the type of expression you hear often in common everyday language so that one could guess the meaning from the context. Hence it would need teaching for it to be clearly known.

It was surprising that observation had the highest percentage of incorrect definitions. Observation would normally be the first science process to be mentioned in the science syllabuses. It is also the science process that is most naturally available and most frequently used by any normal person. Yet, not only does it appear not taught, but even learners at the tertiary level could not articulate any acceptable conception of it. This highly underscores the need for teaching before students can appreciate the underlying constructs for the science processes.

Female Students

In Botswana the drive is strong to encourage female participation in every area of endeavour. Besides, the social structure is such that females learn not to overly depend on males to provide for them. Even though these conceptions may not be taught, my opinion is that female students more than the male students would expend more thought to arrive at acceptable conceptions.

Separate versus Combined sciences

Those who do separate sciences in Botswana are usually the upward bound science stream. They follow more in-depth syllabi and are generally exposed to more laboratory work than the rest in schools. That gives them reasonable edge over the others.

Years of exposure to science teaching and learning

It is a matter of concern that more that 50% of undergraduate science students could not conceptualise the science processes. It is more disturbing that their conceptions of these science processes were not improved by more years of exposure to science teaching and learning. It actually means that just doing science practical work at any level does not by itself impart the conceptual knowledge. It requires focussed teaching effort to impart this conceptual knowledge.

On the whole one could opine that the low percentages who got some of the definitions correct may have achieved it by their personal efforts or they might have been taught by some few exceptional teachers.

Conclusions and Recommendations

The above results have revealed the following about the University of Botswana science students' conceptual knowledge of science processes.

1. Generally the students showed poor conceptual knowledge of science processes, including those fresh from secondary schools (the entering students).
2. Classification was the only science process that up to 23.3% of the respondents gave a correct conceptual definition, followed by communication with 8.2%.
3. Very low percentages of respondents (not more than 3%) gave correct definitions for 10 of

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the 15 science processes.

4. No respondent gave correct definitions for the processes of counting numbers, formulating hypothesis, and making operational definitions.
5. On the whole, there were no significant differences in the mean conception scores of groups within demographic factors of the respondents. Hence the students' conceptual knowledge of science processes was not influenced by any of the demographic factors studied.

It could be noticed that not only has science practical work not enhanced conception of science generally (Hodson, 1993), it has also not enhanced the conception of science processes in particular. Of much concern is the idea that even at tertiary level such conceptual knowledge is not regarded as important and therefore not taught. Gbamanja (1991:123) has suggested that "even though process skills were designed to develop scientific attitudes at the primary school level, it should be an integral part of science teaching at all levels of education." The following recommendations were considered appropriate following the above results and discussion:

i) Science educators in the university should ensure that their students are knowledgeable about the science processes, both conceptually and operationally.
ii) Science teachers should make efforts to teach conceptual and practical knowledge of science processes effectively to science students in the secondary schools.
iii) Analysis of students' conceptions of the science processes should be conducted to identify any misconceptions and to consider ways to remedy them.
iv) International studies may be done to determine the extent of this problem.

Appendix A.

DEFINITIONS, DESCRIPTIONS OR EXPLANATIONS OF SCIENCE PROCESSES

i) Observation is the process of using the senses and their technological extensions to notice objects, events, situations, phenomena, characteristics, properties, etc in the environment.
ii) Classification is the process of putting things into groups based on the similarities and differences in their characteristics, properties, features, etc.
iii) Counting numbers is the process of determining how many units something is. This includes carrying out basic mathematical operations on the numbers.
iv) Measurement is the process of determining the extent or degree a property is present or possessed using appropriate instruments.
v) Inferring is the process of making suggestions or conclusions about a set of conditions based on observations and data.
vi) Communication is the process of using spoken or written language or various forms of graphic representation to pass and obtain information from one person or system to another.
vii) Raising questions is the process of asking in order to gain information and understanding about something.
viii) Formulating hypothesis is the process of making a verifiable statement of relationship between variables based on some observation or information.
ix) Experimenting is the process of conducting a series of practical and mental activities in order to verify hypotheses or theories; it involves many other processes like manipulation, control of variables, measurement, observation, etc.
x) Making operational definitions is the process of defining certain concepts in concrete terms as a way of guiding observation and/or action.
xi) Formulating models is the process of structuring a physical or mental form that can be used to describe the behaviour of something that is not quite familiar.
xii) Interpreting data is the process of treating or transforming data in various ways in order to make sense of it, i.e. to find some pattern or relationships.
xiii) Predicting is the process of forecasting about the future based on past experience, observation or known and reliable information.
xiv) Controlling variables is the process of identifying which variables to keep constant and which ones to change in a systematic way in an investigation or experiment. A variable is controlled when its value is kept constant.
xv) Manipulation is the process of careful and effective use of the body parts, or the application of manual dexterity, for safe and effective handling of objects, living or non-living.

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Hezekiah Ukegbu Emereole

Associate Professor of Science Education, Department of Mathematics and Science Education, University of Botswana, Private Bag UB 00702 Gaborone, Botswana.
Phone: (267) 355 2161; Mobile: (267) 7149 3216
E-mail: emereole@mopipi.ub.bw