

Full Length Research Paper

Factors that impede the formation of basic scientific concepts during teacher training in Ghana

¹Solomon Sarfo and ²Nkopodi Nkopodi

¹Science Department, St. Louis College of Education, Kumasi, Ghana

²Department of Further Education, Unisa, Pretoria, South Africa

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There has been some concern in Ghana regarding teacher trainees' low understanding of basic science concepts. This study was conducted in colleges of education in the Ashanti region of Ghana with the purpose of identifying factors that accounted for the teacher trainees' low understanding of basic scientific concepts and appropriate strategies needed to address this problem. Questionnaires were administered to 80 teacher trainees from four colleges in Ghana to find out their background in science, their attitude towards science, their interest in science and the use of teaching and learning materials in science lessons. These questionnaires also sought to find out the teacher trainees' study techniques and their recommendations for the improvement of teaching and learning of science. In addition, we attended lessons received by teacher trainees and observed teaching strategies in these classes. This was followed by analysis of the questionnaires. We found that the teacher trainees' poor background in science, inflexible teaching methods they received in their science lessons, such as lecturing and provision of pointers to correct answers by their lectures, insufficient use of media integration in science lessons and teacher trainees' poor attitudes towards science learning were some of the factors contributing to this state of affairs. We then recommended that teacher trainees be given activities which included reading assignments, involving them in laboratory work, media integration and by guiding teacher trainees by providing them with plausible explanations with evidence to help the trainees to reject their prior misconceptions.

Keywords: Concept Formation, Teacher Trainees, Integrated Science, Teacher Training Colleges, Misconception, Basic Scientific Concepts, Basic Schools

INTRODUCTION

The research focused on the teaching and learning of Integrated Science to first year Teacher Trainees in Colleges of Education in Ghana. The teacher trainees who have successfully completed the course of study at the Teacher Training Colleges are expected to teach science at basic schools. These teacher trainees are therefore expected to acquire the relevant basic scientific skills that will help them to teach science to pupils in the

basic schools throughout Ghana. The skills that the teacher trainees have to acquire in order to teach effectively at various levels at the basic schools include observation, measuring, calculating, classifying, experimenting, interpreting, drawing, devising and planning investigations, communicating effectively and using materials and scientific concepts to create materials and procedures for solving practical problems.

The Chief Examiner for Science Education at the Institute of Education at University of Cape Coast in his 2006 report on end of first semester Diploma In Basic Education Examination(DBE) results in Integrated

*Corresponding Author E-mail: osarfokofi@yahoo.com

Science for first years had this to say “the majority of the teacher trainees were unable to answer science questions properly during the End of First Semester Examinations in Integrated Science in the first semester, 2005/2006 academic year examinations for Teacher Training Colleges in Ghana. In order to facilitate an understanding of the problem, it is imperative to take cognisance of the fact that the first year students of the Teacher Training Colleges in Ghana gain admission into these institutions based on the fact that they have passed Integrated Science in the Senior Secondary School Examinations and study Integrated Science in the Teacher Training College to consolidate their knowledge is therefore a source of concern to observe that quite a number of the first year Teacher Trainees had to re-sit the Integrated Science paper in their End of First Semester Examinations”. He added that “Most of the teacher trainees who wrote the Integrated Science Examinations in the year 2006 performed below average and lacked the background for the sciences since they could not answer most of the compulsory questions”. He further commented that most teacher trainees could not solve very simple mathematical problems and continued to spell very important scientific words wrongly. The Chief Examiner concluded that the sort of responses teacher trainees produced gave indications that the teaching and learning of science in the Teacher Training Colleges had lost certain fundamental attributes. This has created a situation which actually reduces science to rote learning and which causes candidates to operate mainly at the memorization level at the expense of the other more advanced ways of learning such as comprehension, application, analysis, synthesis and evaluation. Even at the memorization level, many candidates were found wanting since they could not remember definitions, formulae, spellings and chemical equations. He added that the teacher trainees lacked the skill of observation; most of the students could not produce any good diagrams, be it those of experimental set-ups, structures etc. They also did not conform to the laid down rules for making scientific drawings.”

The concerns raised by the chief examiner were not isolated. For example, the Acting Director General of the Ghana Education Service at the opening ceremony of a workshop for the orientation and training of District INSET committee at St. Louis College of Education in Kumasi Ghana had this to say “it is unfortunate that we are still battling with poor students’ performance in schools especially in integrated Science and Mathematics. The results of the National Education Assessment (NEA) and the school Education Assessment (SEA) show a very abysmal performance of students. As the results indicate less than 20% of students in Ghanaian Junior Secondary Schools reach the minimum proficiency in Integrated Science. This he intimated is attributable to teaching that is limited to lecture, chalk and talk and teacher-centered approaches. Junior Secondary School Students do not

participate in science lessons, and have become passive learners with little involvement. These students resort to copying notes from chalkboard and textbooks during integrated science lessons. Teaching and learning are therefore without practice”

Against these concerns this study investigated some of the challenges facing student teachers in their training and sort to answer the following research questions:

Research questions

The following questions are therefore being asked;

- i. What makes it difficult for the teacher trainees to understand basic concepts in science?
- ii. How can teacher trainees be helped to overcome this difficulty?

Concept formation

Human Beings constantly put old concepts to use and in the process, frequently extend them and acquire new, related ones. It is good to know that concept acquisition, formation or development have no end. This is so because at any time in the person's life a new concept can be acquired provided the person is psychologically tuned. The chain of concept usage, enlargement and revision is continuous for as long as we are able to think. Everyone learns concepts, whether they like to or not. Concepts enrich, as well as, extend and order our psychological worlds. Many concepts, such as table are, acquired because they have functional value; useful for something we need or want to do. The process of acquiring and using new concept is described as concept formation.

Roets (1995) observes that the formation of concepts in the cognitive structure is not purely a result of direct observation and past experience, but cognitive process such as organization; interpretation and combination of thoughts play major part. Therefore concept formation and the development of thought go hand in hand, and there is gradual progress from naïve egocentrism to adult logic and objectivity.

Sternberg et al (2001) intimated that one way to promote concept formation is to preview the different concepts students will encounter during the school year or school day or a lesson. They suggested the following strategies;

- a. Teachers are to present learners with the definition of the different types of concepts, telling them which type they will see most and least often in class.
- b. Teachers are to provide learners with examples of important concepts of each type taken directly from their textbooks, class syllabi, and/or outlines.

Teachers are to help students to develop a firm sense of the critical attributes that define individual concepts, making clear that each concept (i.e., separate) may share

some critical attributes with other concepts.

According to Zirbel (2001) a person has a set of intellectual abilities and has developed specific ways of thinking and of surviving in general, and has learned a variety of skills during his lifetime, including how to speak and how to read. The person has a certain database of knowledge that he has acquired over the years. How much of this material is really accessible or there on recall is another issue.

Factors affecting concept formation

Learners have difficulty understanding scientific concepts because they do not have the necessary conceptual, logical and linguistic background (Gaghardi, 1997). Other environmental factors that determine who the student has become are his socio-emotional learning and upbringing. The language and culture certainly affects his characteristics, personal habits, and preset ways of thinking. The parents, specific mentors, relatives and peer opinions and interactions also affect his character and might influence personal his beliefs.

Rosch (1978) believes that in considering how people think about concepts, prototypes often are involved. In prototype matching, people decide whether an item is a member of a category by comparing it with the most typical items of the category. The more similar the item is to the prototype, the more likely the person will judge that it belongs to the category.

Conceptual change

Hewson (1982) describes conceptual change as the process in which the person changes his or her conceptions by capturing new conceptions, restructuring existing conceptions or exchanging existing conceptions for new conceptions, (that is a process of conceptual change).

In the constructivists view, knowledge is a dynamic conceptual means of making sense of experience rather than a passive representation of an extant world. They stress that each person must individually construct meanings of words and ideas if they are to be truly useful (Treagust et al 1996).

Zirbel (2001) however, argued that whether or not a student is going to undergo a conceptual change depends not only on the complexity of the concept itself, but also on the character and upbringing of the student, that is, it involves his entire personality, his general cultural and personal belief systems, his acquires and inherited intellect, his ability to follow and think through arguments and his personal attitude towards undergoing conceptual change.

Steps to facilitate the process of conceptual change

Zirbel (2001) further mentions how a good teacher can help facilitate the process of conceptual change in the following steps.

Step 1: hooking the student (acknowledging information)

From an educational perspective, it is the task of the educator to ensure that the particular idea does get noticed efficiently. In terms of teaching, this might mean that if a new idea is presented the student might need to be told explicitly to pay attention, or is somehow forced into consciously noticing the particular idea that is being presented.

Step 2: suggesting bridges (assimilating information)

Again, this might be the place where a good educator can help the student. Although the student himself has to do the job of assimilating the new knowledge, a good educator might help with meaningful analogies that the student is already familiar with. This might help the student organize his ideas and help activate (hopefully) those networks that will be used later to help solve the problem.

Step 3: querying and confronting the student (accommodating information)

The step of thinking through the problem, understanding it, and more importantly evaluating it, is the hardest part for the student. It requires the reorganization of knowledge, the creating of new neural circuits, and the rewiring of old ones. This is something a teacher cannot do for the student, and his help can only be relatively limited. The student has to be on his own. A good teacher comes in with two things, first he can guide him through the new explanations so that they really do make sense, and second he can help him reject prior beliefs by having the student explain to him why they no longer work.

Step 4: practicing and constructing (familiarizing information)

The work of the teacher certainly does not finish with helping the student understand why his prior theory is not appropriate and why the new theory is so much better. Maybe the student even ends up agreeing and accepts the conceptual change, but this still does not mean that the student can readily apply his newly acquired skills. The student needs to practice, and this is a point where the teacher definitely can help again. He needs to provide the student with meaningful examples and other problems that involve the newly acquired concept. The idea is to make the student feel at ease with the new concept.

METHODOLOGY

The Aim of the Research

The aims of the research are as follows;

Table 1. Teacher Trainees Grade in Integrated Science in Senior Secondary Certificate Examination

Grade	Frequency	Percentage
A	0	0%
B	0	0%
C	2	2.5%
D	18	22.5%
E	60	77%
Total	80	100%

- To find out the obstacles that impede the teacher trainees from forming the correct concepts in Integrated Science.
- To find out why the teacher trainees find it difficult to grasp science concepts clearly during teacher training.
- To find out the appropriate teaching strategies that can be adopted by science tutors in the teacher training colleges that acknowledge, accommodate and provide for the student teachers' prior learning experiences.

Population

The participants were first year teacher trainees, since the first year teacher trainees study Integrated Science concepts during their first year and have to apply the concepts in the second year when they study science methodology which they apply during their professional development in third year when they undertake a one year internship in basic schools in rural areas. The first year teacher trainees who were involved in the study were assured of confidentiality.

Sample

The sample was chosen from the first year teacher trainees who had grade E in Science during the end of first semester examination in the 2005/2006 academic year. Eighty teacher trainees who had grade E in integrated Science were purposefully selected from four Colleges of Education in the Ashanti region. These four Colleges of Education were used for the investigation because they were easily accessible.

Ethical Issues

The ethical measures that were undertaken included consent from the heads of science departments and the first year teacher trainees who were purposefully sampled. They were assured of anonymity and confidentiality.

Instrument

The data gathering instrument used in this research was questionnaire that sought to establish the teacher trainees background in Science, their attitude and interest in Science, their involvement in the use of teaching and learning materials, their preparedness to use reference textbooks and to do assignments in Science. In addition, we attended lessons received by teacher trainees and observed tendering strategies in these classes

Data collection procedure

The questionnaire were distributed and administered by science tutors in the four selected Colleges of Education on pre-arranged date. The responses to the questions were retrieved after five days to ensure that enough time had been given to the respondents to think about the questions and offer their answers.

Data analysis

The responses that were obtained from the tender trainees were put on tables and their frequencies and percentages were calculated and discussed using a comparison of the percentages. Also the responses were analyzed using quantitative strategies such as categorization, interpretation, noting patterns and themes.

RESULTS

The responses in the tables relate to the following questions

- State your grade in Integrated Science in the Senior Secondary Certificate Examination.
- All teacher trainees should learn Integrated Science.
- If you are given the option, will you avoid Integrated Science?

Table 2. Teacher Trainees' views on Integrated Science as a Foundation Course

Responses	Frequency	Percentage
1. Disagree completely	26	32.5%
2. Agree partially	22	27.5%
3. Agree	14	17.5%
4. Agree completely	18	22.5%
Total	80	100%

Table 3. Teacher trainees' reasons on why integrated science should not be studied by all teacher trainees

Reasons	Frequency	Percentage
1. Not all the teacher trainees specialized in Science at Senior Secondary School	46	57.5%
2. Teacher Trainees should not be forced to study Integrated Science if they are not science-biased	22	27.5%
3. The Teacher Trainees may not study Science for further studies	18	22.5%
Total	80	100%

Table 4. The amount of time teacher trainees use to study science privately.

Reasons	Frequency	Percentage
4. Not all the teacher trainees specialized in Science at Senior Secondary School	46	57.5%
5. Teacher Trainees should not be forced to study Integrated Science if they are not science-biased	22	27.5%
6. The Teacher Trainees may not study Science for further studies	18	22.5%
Total	80	100%

- iv. How much time do you spend studying Integrated Science during your private study time during the week?
- v. State any study technique you used in studying Integrated Science.
- vi. How is your interest in Integrated Science?
- vii. What quantity of teaching and learning materials is available in your college for science teaching?
- viii. Can you suggest any ways by which the teaching and learning of Integrated Science can be improved in Colleges of Education?

From table 1, majority of the teacher trainees (77%) scored lower grades in Integrated Science at the senior secondary school examination. This indicates that the teacher trainees have poor background in science that may contribute to their holding of naïve and inaccurate knowledge in science which is resistant to change and may impede the formation of science concept.

From tables 2 and 3 majority of the teacher trainees disagree that all the teacher trainees should learn Integrated Science during teacher training. Also, majority of them explained that only a few of the teacher trainees

specialized at the senior secondary school and also few may study science for further studies. This stand by the teacher trainees indicate that they had negative attitude towards the teaching and learning of Integrated Science and since their background knowledge in science is poor, it stands to reason that they will disagree that science should be a compulsory subject during teacher training.

From tables 4 and 5, majority of the teacher trainees learn Integrated Science when they are going to either write a quiz or preparing for an examination. This simply reveals that the teacher trainees are not motivated to learn Integrated Science and so this has contributed to inadequate library and research skills. Also, majority of the teacher trainees spent insufficient time in studying Integrated Science and the conclusion that can be drawn from this is that because of their poor background in science they are not motivated to learn science and spend less time in learning science.

From table 7, 85% of the teacher trainees are not interested in Integrated Science

It can therefore be deduced that since they have poor background knowledge in science they will develop a

Table 5. Teacher trainees' study techniques

Responses	Frequency	Percentage
Always (before science lessons)	17	21.2%
Sometimes (prepare for a test)	39	48.8%
Not at all	24	30%
Total	80	100%

Table 6. Percentage of teacher trainees who wants to avoid the learning of integrated science

	Frequency	Percentage
Yes	65	81.25%
No	15	8.75%
Total	80	100%

Table 7. Teacher trainees level of interest in integrated science.

Interest in Integrated Science	Frequency	Percentage
Very strong	0	0%
Strong	12	15%
Low	68	85%
Very low	0	0%
Total	80	100%

Table 8. Use of teaching and learning materials in science teaching

Use of teaching and learning materials	Frequency	Percentage
Very adequate	0	0%
Adequate	12	15%
Less adequate	68	85%
Not available	0	0%
Total	80	100%

strong negative attitude towards science and may find the learning of science not attractive.

From table 8, majority of the teacher trainees (85%) indicated that the teaching and learning materials were not adequate in the teaching of science. This revealed that most science lessons were conducted without the use of teaching and learning materials.

DISCUSSION OF RESULTS

Perception of teacher trainees on integrated science

Fifty seven point five percent (57.5% (table 3)) of the teacher trainees explained that science should not be a foundation course at the College of Education because

not all the teacher trainees specialized in science at the senior secondary schools. This shows that quite a number of the teacher trainees believe that if one does not do elective science at senior secondary school level, that person should not be compelled to study Integrated Science. Twenty two percent (22.5% (table 3)) also explained that, if after completing teacher training they will not teach science then, it is not advisable for the teacher trainees to learn science during teacher training. This shows that over 20% of the teacher trainees were not in favour of making science a foundation course since they were not sure of when they were going to apply the knowledge in science in future. The implication is that majority of the teacher trainees had a wrong perception about Integrated Science. This perception is illustrated by the responses on table 2 which showed that 32.5% of the

Table 9. Suggestions made by teacher trainees for the improvement of the teaching and learning of Integrated Science in colleges of education.

Ways to improve Science teaching and learning	Frequency	Percentage
1. Science Tutors should try to explain concepts using simple English Language or in vernacular	27	33.7%
2. Integrated Science lessons must be held always in the Science laboratory so that the students get the exposure to scientific equipment.	28	35%
3. Integrated Science lessons should be tailored for only Teacher Trainees who would like to teach science at the Primary Schools.	25	31.3%
Total	80	100%

teacher trainees disagreed completely that Integrated Science should be a foundation course in the Colleges of Education. This shows that over 32% of the teacher trainees are not interested in science. Further more, from table 7, 85% of the teacher trainees expressed low interest in science, while only 15% expressed strong interest in science. Thus majority of the teacher trainees were not interested in science. It can therefore be concluded that majority of the teacher trainees have negative attitude towards Integrated Science and so exhibited low interest in studying in the subject.

Poor class participation

Observations made from science lessons revealed that majority of the teacher trainees did not actively participate in science lessons. The teacher trainees remained passive and only participated in notes taking. They seldom asked questions during science lessons and gave totally wrong answers to some basic questions; for example, some were not particularly interested in grasping the fact that cell wall was a plant cell inclusion, and so emphatically asserted that cell walls are found in animals cells.

Secondly, most of the teacher trainees seemed not to concentrate in science lessons. This was obvious when the science tutors frequently reminded these teacher trainees that they should not put the head on the table. Some of them were also found either trying to refer from some prepared notes to give the impression that they had grasped a concept, whereas they were contributing by reading from prepared notes. The students lacked the appropriate observational skills, recording skills and communication skills.

Another predominant feature in science lessons was that almost all the lessons were teacher-dominated lessons. The teacher trainees were seldom provided with the opportunities to physically interact with instructional materials and also were not given the opportunity to engage themselves in varied kinds of activities.

Poor study skills

The responses in table 5 showed that, 66.3% of the teacher trainees do not learn science as they only learn science when they are going to write a quiz, while only 21.2% read their notes before they attend science lessons. This shows that, the teacher trainees do not have private study schedules for science. Sixty-six point three percent (66.3%) of the teacher trainees study science when they are going to write examination, twenty-one point two percent (21.2%) read the notes before they attend Integrated Science lessons while twelve percent (12%) join their friends for discussions. This implies that, most of the teacher trainees do not employ any study technique when studying science (Table 5).

The responses in table four (4) showed that 87.5% of the teacher trainees study science for between one and two hours at their private study time while only 12.5% study science between two and three hours. This showed that majority of the teacher trainees spend less time to study science. Thirty (30%) of the teacher trainees do not study science at all during their private study time, forty-eight point eight percent (48.8%) study science at times while twenty-one point two percent (21.2%) always study science. This implies that thirty percent (30%) of the teacher trainees lacked the motivation to learn science during their study time (Table 5b).

From the above, it can be concluded that, the teacher trainees lack the techniques of studying Integrated Science and do not think that studying Integrated Science need any special techniques.

Suggestions for improvement of teaching of science

Table 9 shows that a large number of teacher trainees have different ways of improving the teaching and learning of Integrated Science in teacher training colleges. The teacher trainees therefore suggested different ways like clear explanation of science concepts during science lessons and conducting science lessons in science laboratories where teacher trainees interact

with science equipment. This shows that there are deficiencies in the teaching and learning of science in the teacher training colleges and these deficiencies need to be rectified.

Fifty-seven point five (57.5%) of the teacher trainees (table 3) suggested that the teaching of Integrated Science should be limited to only teacher trainees who have already specialized in science at the Senior Secondary School. The implication is that science should be a specialized subject, which should be selected by only the teacher trainees who studied science as elective in Senior Secondary School.

Twenty-Seven point five percent (27.5%) of the teacher trainees suggested that the students should not be compelled to study Integrated Science if they are not Science biased (table 2). This shows that some of the teacher trainees feel compelled to study science and do not show any commitment into the study of science.

Thirty-two point five percent (32.5%) of the teacher trainees disagreed completely while twenty-seven point five percent (27.5%) agreed partially to the notion that teacher trainees should learn Integrated Science (table 2). The implication is that, the teacher trainees felt that there is no need to make science a compulsory subject at the teacher training colleges.

Thirty-three point seven percent (33.7%) of the teacher trainees suggested that science concepts should be explained in vernacular. Thirty-five percent (35%) suggested that science lessons should be held in laboratories while thirty-one point three percent (31.3%) suggested science teaching at the teacher training colleges should be given to only the students who would be teaching science at the basic schools. The implication is that, the teaching of science in the teacher training colleges does not employ appropriate teaching techniques and moreover, the teacher trainees are not exposed to experimental procedures in the laboratories. Also, the teacher trainees wanted scientific concepts to be explained using vernacular and science teaching should be limited to only teacher trainees who specialised in science at secondary school.

Teacher trainees' poor background in science

Every educational programme has a baseline and a ceiling. This baseline is a starting point which in most instances assumes that learners entering into a programme have already acquired basic knowledge and skills relevant to their understanding of the new content.

However, the majority of the teacher trainees' performance in the Senior Secondary School Certificate Examination was just average, that is Grade E which is interpreted as a pass. This weak foundation is traceable to their junior high school days. This indicated that what majority of the teacher trainees ought to know in science

already to assist them to understand science concepts was inadequate.

This assertion is further buttressed by the fact that the teacher trainees' poor background in science resulted in their holding to naïve conceptions about science which further resulted in marked resistance to change. The teacher trainees' previous incomplete and incorrect knowledge in science might have interfered strongly with what their teachers conveyed in class. It therefore stands to reason that the teacher trainees' poor background in science contributed to their low understanding of science concepts.

Inflexible teaching methods

A good teacher is supposed to guide students through any new concept and also to help students to reject prior beliefs. The good teacher does this by trying to provide students with exactly the defects regarding the beliefs they hold and continuously challenge the students and also providing the students with meaningful examples and other problems that involve the newly- acquired concepts.

However Inflexible teaching methods, for example, lecturing, reading from text books and science tutors providing too many pointers to correct answers were used in the teaching of science. The science tutors did not motivate the students. Also, the competence of some of the science tutors during science lessons was not encouraging, therefore the teacher trainees have negative attitude towards the learning of science.

CONCLUSIONS

The Teacher Trainees are supposed to learn science concepts, remember what they have learnt and then apply the knowledge in unfamiliar situations to solve problems. In this way, they will be developing skills in the areas of understanding, evaluating, synthesizing, and drawing conclusions, seeing cause and effect, mastering technique of notes taking and research. This required the employment of appropriate study skills to learn science concepts and developing positive attitudes towards the learning of science. However, basic and elementary scientific phenomena and explanation were beyond the reach of the teacher trainees. They were not familiar with common concepts such as electrostatics, magnetism, refraction, momentum, speed, acceleration, work and energy and force in the physical sciences. They displayed poor mastery of these science concepts and understanding and that their understanding was limited to their own experience, social knowledge and prior learning experiences.

RECOMMENDATIONS

Strategies to be employed to find solutions that will help the teacher trainees to understand basic scientific concepts.

- a. The science tutors at the teacher training colleges must endeavour to help the teacher trainees to undergo appropriate conceptual change and form basic scientific concepts by following the principles underlined below:
 - i. The teacher trainees must be made to pay attention when a new idea or new concept is being presented and the new idea should be presented clearly in a language that the teacher trainees will understand.
 - ii. The new ideas must be presented in a simplified fashion so that the teacher trainees can follow every part of the argument clearly.
 - iii. The teacher trainees must be guided by the science tutors by providing them with plausible explanations of concepts and also providing evidence that will enable the teacher trainees to reject their prior misconceptions. This can be done by asking the teacher trainees to provide their views on concepts and challenging them to justify their explanations.
 - iv. The teacher trainees must be guided to relate the new concepts to their real life situations. The science tutors in teacher training colleges must endeavour to

help the teacher trainees to put into practice what they have learnt by providing the teacher trainees with meaningful examples and other problems that involve the newly acquired concept.

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