Comparison of Science Teachers in Selected Basic Schools in Ghana with Reported Data from Five Developed Countries in TIMSS 1999 Video Study

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Abstract

This study compared science instruction between selected science teachers from 20 junior high schools (JHS) in Ghana and the five developed countries namely: Australia, Czech Republic, Japan, Netherlands, and USA, that took part in the Third International Mathematics and Science Study (TIMSS) 1999 video study. A survey was carried out using slightly modified TIMSS 1999 video study questionnaire to compare the factors that influence science teachers' actions in Ghana with those from the five developed countries. It was revealed that science teachers from the developed countries possessed higher degrees than those from Ghana. Professional development activities of the science teachers in Ghana basically focused on science instructional techniques but are more diversed in the developed countries. Furthermore, curriculum guidelines and mandated textbooks significantly influenced decisions to teach lesson content in Ghana and Czech Republic; teachers' assessment of students' interest greatly influenced lesson content in USA; and external examination and standardized tests shaped lesson content a great deal in Ghana only.

1. Introduction

1.1. Background to this study

Scientific literacy is well cultivated in the classroom through instruction. The way science teachers behave in class will determine the effective development of scientific knowledge among students. Instructional behaviors of science teachers are those actions and teaching practices exhibited by them in class intended to bring about a change in behavior in the students. In order words, this is basically how science teachers behave in class during teaching and learning, which includes actions such as teaching methods and strategies.

Science instruction nurturing individuals to acquire desirable knowledge, skills and attitudes greatly depends on teaching practices. Exemplary teaching practices have been identified as helping to improve the quality of classroom instruction. For example, exemplary teachers have greater representational and adaptational repertoire for teaching basic concepts (Clermont et al., 1994). They set academic tasks that are cognitively demanding (Treagust, 1999), and

apply science to real life situations outside the classroom (Tobin & Garnett, 1988). They also "utilized strategies that encouraged students to participate in learning activities" (Tobin & Fraser, 1990, 14), and "were effective in a range of verbal strategies which included asking questions to stimulate thinking, probing student responses for clarifications and elaboration, and offering explanations to provide students with additional information" (ibid., 13). Other exemplary classroom practices show that teachers assessed student understanding through content and practical tests, and project work, organized the use of equipment very well and efficiently distributed to the class, quickly detected off-task behavior and responded appropriately to them, and were conscious of time management and used certain organizational skills during activity based lessons (Goodrum, 1987). These exemplary teaching practices exert a strong influence on enhancing classroom instruction. But, in African contexts, teaching practices are typified by teacher presentation of facts and students being tasked to memorize correct answers or procedures rather than being encouraged to create knowledge by themselves (Akyeampong et al., 2006).

In Ghana, basic education is made up of six years primary school (PS) and three years junior high school (JHS). Basic education is essential to national development (Ahmed et al., 1991; Rogan et al., 2008) but, it is faced with many problems in the country. For instance, instructional behavior of science teachers is also centered on rote learning and memorization of facts (Fredua-Kwarteng & Arhia, 2005). Science teachers' behavior in class include actions and teaching practices such as a 'chalk and talk' approach, reading from textbooks, and copying and dictating notes for students to write down (Quartey, 2007). They also "integrate textbooks into instruction by copying passages and exercises from the textbooks onto the chalkboard and then engaged the pupils on the chalkboard" (Okyere, 1999, 72). Many science teachers also prefer students to reproduce what they teach and the notes they give, and this limits critical thinking and creativity on the part of the students (Quartey, 2007). Furthermore, "child-centered techniques such as pair-sharing, pyramiding, group discussion, panel presentation, debates, co-operative learning are completely absent in Ghanaian classrooms" (ibid., 4). These studies do not reveal exemplary practices that would facilitate science instruction in the classroom, and consequently, would not promote the teaching and learning of science. Therefore, there is the need to compare the factors that influence instructional behaviors of science teachers in Ghana with the five developed countries in order to seek ways to improve science instruction in basic schools in Ghana.

1.2. Purpose of this study

This study compared science teachers' education preparation, professional development opportunities, time spent on different school activities, learning goals for science lessons, and decisions to teach lesson content between the participants who took part in this study in Ghana and those from the five countries that participated in the Third International Mathematics and Science Study (TIMSS) 1999 video study in science.

2. Method

Twenty junior high schools were selected in this study in Ghana. There were 83% males and 17% females. The average age of the science teachers in this study was 29 years. This study was conducted, as part of a preliminary video study in five districts in Ghana in February-March 2008 and February-March, 2009, using purposeful sampling. Twenty-three science teachers in Ghana took part in a questionnaire survey, and TIMSS 1999 Video Study Australian science teacher questionnaire items that focused on factors that influence how science teachers behave in class are discussed. Some of the items were slightly changed and other new items were added (Appendix I). These items were slightly changed or newly added to be culturally responsive. The questionnaire data was tabulated into percentages and averages.

3. Results

3.1. Science teachers' education preparation

Most science teachers in this study in JHS in Ghana have qualifications below undergraduate degree compared to those from JHS in Australia, Czech Republic, Japan, Netherlands and USA (Table 1). In these countries[1] most science teachers have either graduate degrees or undergraduate degrees. A few science teachers in this study in Ghana have either undergraduate degrees or high school certificate.

Table 1: Distribution of science lessons by teacher's highest level of education in Ghana and other countries.

Country	Highest level of education/%			
	Graduate degree	Undergraduate degree	Below undergraduate degree	High School Certificate
Ghana[2] (N=23)	0	13	83	4
Australia (N=87)	11	85	4	0
Czech Republic (N=88)	100	0	0	0
Japan (N=95)	8	92	0	0
Netherlands (N=79)	39	61	0	0
USA (N=84)	39	61	0	0

The majority (67%) of the science teachers in this study in Ghana majored in 'other than science' (non-science) subject areas and none majored in Life Sciences, Physics, Chemistry and Earth Sciences (Table 2). The rest (33%) majored in General Science (Appendix I, 1a, 1b and 1c). However, science teachers, mainly majored[1] in the science disciplines in Australia, Czech Republic, Japan, Netherlands, and USA.

Table 2: Science lessons taught by teacher's major in Ghana and other countries.

Major area of study	Ghana /%	Australia /%	Czech Republic /%	Japan /%	Netherlands /%	USA /%
Life Science	0	47	48	20	4	4
Physics	0	15	33	30	44	0
Chemistry	0	29	32	31	37	4
Earth Sciences	0	11	48	10	6	6
General Science	33	4	0	100	0	11
Science-Total	33	87	95	100	99	64
Other than science	67	13	5	0	0	36

The science teachers in this study in Ghana have an average teaching experience of 6 years in overall teaching and 4 years of teaching science but the overall teaching experience and the number of years of teaching science in the other countries[1] ranged from 12 -21 years and 10-19 years respectively (Table 3).

Table 3: Summary and dispersion measures for science teacher's teaching experience in Ghana and other countries.

Teaching experience	Statistic	Ghana /yrs	Australia /yrs	Czech Republic /yrs	Japan /yrs	Netherlands /yrs	USA /yrs
Years teaching[3]	Mean	6	15	21	15	14	12
	Median	4.0	16	21	15	11	7
	Range	1-11	0-39	1-41	1-34	1-36	1-35
Years of teaching science[4]	Mean	4.0	14	19	14	12	10
	Median	4.0	15	18	15	9	7
	Range	1-9	0-39	1-39	1-34	1-33	1-35

3.2. Professional development opportunities

Forty five per cent of the lessons in this study in Ghana were taught by science teachers who had taken some diploma courses prior to this study, and 38-56% of the lessons in Czech Republic, Japan, Netherlands and USA were taught by science teachers who took at least one science or science education university course[1] (Table 4). However in Australia[1], only 9% of the lessons were taught by science teachers who had that experience (Appendix I, 3a and 3b). The average number of professional development activities in Ghana was 3 and in the other countries[1] this ranged from 2-5 (Table 4).

The science teachers in Ghana (54%) reported that they mainly take part in professional activities focusing on science instructional techniques (Table 5) whereas their counterparts in the other countries[1] participate in diverse professional development activities (Appendix I, 4a and 4b).

Table 4: Science lessons taught by teachers who participated in science- related education courses and average number of professional development activities in Ghana and other countries.

Country	Lessons taught by teachers who took at least one science/ science education/education course/%	Average number of professional development activities[5]
Ghana	45	3
Australia	9	3
Czech Republic	56	2
Japan	38	2
Netherlands	50	2
USA	49	5

Table 5: Percentage of science lessons by teachers' participation in professional development activities or academic courses in Ghana and other countries.

Professional development activity	Ghana /%	Australia /%	Czech Republic/%	Japan /%	Netherlands /%	USA /%
Classroom management and organization	5	37	6	19	16	21
Cooperative group instruction	0	29	7	12	36	48
Interdisciplinary instruction	0	14	5	-	3	48
Science instructional techniques	54	36	36	50	43	66
Standards-based teaching	0	36	0	29	22	52
Teaching higher-order thinking skills	0	22	0	0	11	44
Teaching students from different cultural backgrounds	0	13	0	0	8	31
Teaching students with limited proficiency in their national language	0	5	0	0	5	18
Teaching students with special needs	0	23	7	6	12	36
Use of technology	14	79	45	42	68	84
Other professional development activities	18	46	42	18	25	44

3.3. Science teachers' time spent on different school activities

Science teachers in this study in Ghana spent an average of 28 hours per week on all teaching and other school-related activities, and the results from the TIMSS 1999 video study revealed that science teachers in Australia, Czech Republic, Japan, Netherlands and USA reported spending an average time on all teaching and other school-related activities ranging from 38-45 hours per week[1] (Table 6). Science teachers in Ghana, therefore, spent a smaller average number of hours on all teaching and other school-related activities than their counterparts in the other countries.They

Table 6: Average weekly hours science teachers spent on teaching and other school related activities in Ghana and other countries.

Activity[6]	Ghana	Australia	Czech Republic	Japan	Netherlands	USA
Teaching science class	7	14	16	16	19	20
Teaching other classes	8	3	6	1	4	4
Meeting with other teachers to work on curriculum and planning issues	3	2	1	1	1	2
Work at school related to teaching science	3	7	6	6	4	7
Work at home related to teaching science	3	6	6	4	7	6
Other school-related activities	4	5	7	12	5	6
All teaching and other school-related activities	28	38	42	40	40	45

also reported spending an average of 7 hours in a week teaching science classes, and compared with the results of the TIMSS 1999 video study, it is seen that science teachers who participated in that study reported spending between 14 and 20 hours in a week teaching science classes[1]. Science teachers in this study in Ghana, therefore, spend about half the time used by the countries that participated in the TIMSS study in a week teaching science classes. Furthermore, they reported spending an average of 8 hours in a week teaching other classes, and compared to science teachers in Australia, Japan, the Netherlands and USA this is about twice more than the time used in these countries[1]. However, the number of hours[1] that science teachers in Czech Republic spent on teaching other classes was about the same as in Ghana.

Science teachers in Ghana reported spending 3 hours per week for meeting with other teachers to work on curriculum and planning issues and compared with the countries that took part in the TIMSS 1999 video study, it is seen that science teachers from these countries spent between 1 and 2 hours[1] on meeting with other teachers to work on curriculum and planning issues. The science teachers in Ghana also spent 3 hours per week each on work at school related to teaching science, and work at home related to teaching science and those from the other countries spent between 4 and 7 hours per week[1] on the same activities. Additionally, in Ghana, the science teachers spent an average of 4 hours on other school-related activities in a week, and in Australia, Czech Republic, the Netherlands and USA, according to the results of the TIMSS 1999 video study, the science teachers also spent between 5 and 7 hours[1] weekly on other school related activities. However science teachers in Japan spent 12 hours in a week on other school-related activities.

3.4. Science teachers' learning goals for science lessons

Science teachers in this study in Ghana mainly focused on knowing science information, followed by awareness of the usefulness of science in life rather than understanding scientific ideas and doing science (Table 7). On the other hand, science teachers from the other countries spread their foci on knowing and understanding of science,

Table 7: Percentage of lessons by teacher-identified goals in Ghana and other countries.

Goal for the lesson[7]		Ghana /%	Australia /%	Czech Republic /%	Japan /%	Netherlands /%	USA /%
Knowing and understanding science	Knowing science information	75	20	59	14	23	23
	Understanding scientific ideas	0	51	7	70	27	23
	Understanding nature of science	0	4	0	0	0	4
Doing science	Carrying out a scientific experiment, project, or activity	4	4	6	10	15	17
	Developing generic thinking skills	0	0	0	3	8	5
	Learning laboratory skills	0	11	10	15	12	6
	Using scientific inquiry skills	0	13	6	8	11	22
Context of science	Awareness of the usefulness of science in life	21	19	12	9	17	22
	Collaborative work in group	0	0	0	0	10	8
	Independent work	0	5	0	3	11	7

doing science, and context of science, although the extent of foci differ from country to country (Table 7). There is a remarkable difference between science teachers in this study in Ghana and those from Japan. For instance, whereas 75% and 0% of the science teachers in Ghana reported focusing on knowing science information and understanding scientific ideas respectively, 14% and 70% of the science teachers in Japan focused on knowing science information and understanding scientific ideas respectively.

3.5. Science teachers' decision to teach the content of lessons

Curriculum guidelines, mandated textbooks, and external examination and standardized tests greatly influenced decision to teach lesson content in at least 70% of the lessons in this study in the selected basic schools in Ghana (Table 8). Compared with the other countries that participated in TIMSS 1999 video study, it is seen that curriculum guidelines greatly influenced decision making in at least 60% of the lessons in Australia, Czech Republic and the USA, and mandated textbooks played a major role in selecting lesson content in at least 52% of the lessons in Czech Republic, Japan and the Netherlands[1].

Furthermore, teachers' assessment of students' interest/needs, played a role in the decision to teach lesson content in 53% of the lessons in this study in Ghana, but compared to the results of TIMSS 1999 video data, science teachers in 74% of the lessons in USA reported that this greatly influenced their decision, and between 25% and 47% of the science teachers in the other countries reported that this influenced their decision[1] (see Appendix I, 5a and 5b).

Table 8. The percentage of teachers who agree on the items as major factor in the decision to teach lesson content in Ghana and other countries.

Factor	Ghana /%	Australia /%	Czech Republic /%	Japan /%	Netherlands /%	USA /%
Cooperative work with other teachers	27	32	6	5	44	25
Curriculum guidelines	76	60	93	20	41	84
External examinations & standardized tests	72	-	3	5	7	23
Mandated textbooks	78	32	67	52	74	26
Teacher's comfort or interest in the topic	40	27	47	15	37	41
Teacher's assessment of students' interest / needs	53	47	39	44	25	74

Cooperative work with other teachers and teacher's comfort or interest in the topic exerted the least influence on decision to select lesson content in this study in Ghana, and the TIMSS 1999 video study also revealed a similar pattern among the countries that participated in the study[1].

4. Discussion/implications

4.1. Science teachers' education preparation

Many of the science teachers in this study in Ghana possessed certificates below undergraduate degree because they mainly went through a 3-Year Post Secondary Teacher Training College education. Most of them completed nine years of basic education, three years of high school education and finally enrolled in the teacher training colleges where they spent three years. On the other hand science teachers in Australia, Czech Republic, Japan, Netherlands and USA pursued the science disciplines in the universities.

In Ghana, the 3-Year Teacher Training College that the science teachers in this study attended did not prepare them in science disciplines like life sciences, physics, chemistry and earth science. They were mainly nurtured in general science and other subject areas. Science teachers need to have deep knowledge in the various science disciplines so it is necessary for the teacher training institutions to teach the various disciplines as individual subjects.

4.2. Professional development opportunities

Professional development is the key to improving the quality of science teaching. Since majority of the teachers in this study in Ghana did not major in science in the teacher training colleges, as compared to their counterparts from the five developed countries, it is necessary for science teachers in Ghana to engage in regular in-service training activities in order to learn more about science and share their experiences and ideas. Professional development activities should focus on diverse activities like cooperative group instruction, interdisciplinary instruction, standards-based teaching, teaching higher order thinking skills, teaching students from different cultural backgrounds and with limited proficiency in English language, education technology, and classroom management and organization.

4.3. Science teachers' time spent on different school activities

The small number of hours spent by science teachers in this study in Ghana compared to the other countries is due to the fact that the science teachers are doing another job like teaching extra classes for personal gains. The reason why science teachers in Ghana reported spending many hours teaching other classes, is due to the fact that there are inadequate teachers in the basic schools in Ghana so they are compelled to teach other subjects.

Science teachers in Ghana, like their colleagues who participated in TIMSS 1999 video study, reported spending the least average number of hours on meeting with other teachers to work on curriculum and planning issues, mainly because they are not involved in curriculum development planning issues. The local and regional offices of the Ghana Education Service and the school administration should greatly involve teachers in issues relating to curriculum and planning. This, when practiced, would cultivate the habit of meeting with other teachers to work on such issues.

Japanese science teachers spent the highest number of hours on other school related activities because they are generally involved in extra activities like class and grade activities, home room responsibilities, teaching period of integrated studies, and moral education.

4.4. Science teachers' learning goals for science lessons

The results in Table 7 is due to the fact that the science teachers in this study in Ghana and those in the other countries have different social backgrounds and working conditions. For instance in Japan, science teachers have access to well equipped facilities in the schools, whereas science teachers in Ghana have limited access to equipment and facilities. Furthermore, the science teacher in Japan spends almost the whole day at school but his counterpart in this study in Ghana spends about half a day at school. Therefore, there is the need to create a social environment and working conditions that will promote science instruction in Ghana.

In addition, science teachers in Ghana need to emphasize understanding of scientific ideas and concepts during science lessons. Although 21% of the science teachers in this study in Ghana reported that they focus on creating awareness of the usefulness of science in life (Table 7), the understanding of science concepts and ideas is paramount. Without the understanding of science concepts, patterns, theories and ideas, children may be aware of the usefulness of science but cannot make use of scientific knowledge in their everyday life activities. Therefore, science teachers need to focus not only on knowing but also understanding of science; doing science such as carrying out scientific experiment, project or activity, developing generic thinking skills, learning laboratory thinking skills, and using scientific inquiry skills; and context of science like awareness of the usefulness of science in life, collaborative work in groups, and independent work.

4.5. Science teachers' decision to teach the content of lessons

Curriculum guidelines, mandated textbooks and external examination greatly influenced instructional behavior among the science teachers in this study in Ghana because science teachers mainly use curriculum materials specified by the government like science syllabus, mandated textbooks and Basic Education Certificate of Education (B.E.C.E.) examination past questions. For instance, every teacher uses the science syllabus to determine the lesson content to be taught because the syllabus has specified objectives, activities and assessment procedures to serve as a guide for the teacher. Science teachers in Ghana also use mandated textbooks because every student is expected to have access to one at school. These are the primary source of reference materials for them. Hence, they heavily rely on them for familiarity with the content.

Additionally, B.E.C.E. examination past questions greatly influence the instructional behaviors of teachers because, generally, science teachers in Ghana are highly stressed because they have to prepare their pupils to pass the national examination for completing the compulsory basic education. Science teachers, therefore, teach according to the nature of the B.E.C.E examination past questions. The fact that exit examinations are used as criteria for selecting students to pursue their education in the senior high schools in Ghana encourages the science teachers to prepare their students towards passing the examinations. As a result of this, the teaching and learning of science shapes pupils behaviors towards passing the examinations. Science teaching, therefore, focuses on knowledge acquisition by pupils so the teacher education system should be structured such that teacher trainees would have autonomy and be innovative rather than relying heavily on curriculum guidelines, mandated textbooks and B.E.C.E. examination past questions. This will produce science teachers who will make science teaching productive to meet the contemporary changes in science education.

Science teachers in Ghana need to be sensitized that other factors like teacher collaboration and teacher's assessment of student's interests/needs, play a major role in selecting lesson content, and influence their behavior. For instance, verbal discussion of ideas and best ways to teach science topics will help science teachers to expand their knowledge in both content and pedagogy. Collaboration among teachers will also enable them to share new information about science on current issues in science education. Furthermore, since teachers have specific major fields of study, interacting with other colleagues helps those with little knowledge in certain disciplines acquire deeper understanding from their colleagues with immense knowledge in these areas. The science teachers need to have adequate assessment of their students' interests or needs to enable them to diagnose students' weakness and strengths. Adequate knowledge about students' interests, thinking, difficulties, needs, weaknesses and strengths will enable science teachers to select appropriate content and plan desirable activities.

5. Limitation of this study

The behavior of the science teachers selected for this study show actions and teaching practices of some science teachers in selected basic schools in Ghana, and thus, cannot be generalized for the whole country. Logistical constraints did not allow the researcher to use probability sampling to cover all the regions in the country.

6. Conclusion

Generally, the factors that infruence instructional behaviors of science teachers in this study in Ghana differ from those in the five developed countries who took part in TIMSS 1999 video study. For instance, many of the science teachers in Ghana possessed certificates below undergraduate degree whereas their counterparts in Czech Republic, Japan, Netherlands and USA possessed mainly undergraduate degrees. Science teachers from Czech Republic possessed mainly graduate degrees. Furthermore, professional development activities of the science teachers in Ghana, unlike their counterparts in the five developed countries, mainly focus on science instructional techniques, and downplay classroom management and organization, the use of technology, and other professional development activites. Professional development of science teachers in the developed countries target diverse activities. Moreover, in Ghana, professional development activities do not target diverse activities like cooperative group instruction, interdisciplinary instruction, standards-based instruction, and teaching higher order thinking skills.

Generally, science teachers in this study in Ghana spent a smaller average number of hours on all teaching and other school-related activities than their counterparts in the five developed countries. Their learning goals are driven toward knowing science information, followed by creating awareness of the usefulness of science in life, rather than understanding scientific ideas and doing science. On the contrary, science teachers from the developed countries spread their learning goals on knowing and understanding of science, doing science, and the context of science.

Additionally, curriculum guidelines significantly formed the basis for decisions to teach lesson content in Ghana, Australia, Czech Republic and USA; mandated textbooks greatly shaped lesson content in Ghana, Czech Republic, Japan and the Netherlands; and teachers' assessment of students' interest notably influenced lesson content in USA, and to some extent in Ghana, Australia, and Japan. However, external examination and standardized tests considerably influenced lesson content in Ghana only.

Appendix I: questionnaire items

TIMSS item		Slightly modified TIMSS item/Item used in Ghana	
1a	What was your undergraduate major field of study?	1c	What was your major field of study in the Teacher Training College?
1b	What was your major field of study at post graduate level?		
3a	During the last two years, how many university courses have you taken in science or science education?	3b	During the last two years, how many university courses have you taken in science or education?
4a	During the last two years, have you participated in professional development activities or taken courses in any of the following?	4b	Have you participated in professional development activities or taken courses since you started teaching in any of the following?
5a	Which of the following played a role in your decision to teach this content?	5b	Which of the following played a role in your decision to teach this content? The option of one of the items focusing on the factors that influence the teacher's decision to select lesson content was changed from 'national, state, or school curriculum guidelines' to 'national curriculum guidelines', and the option 'Basic Education Certificate of Education past questions' was added to the other options for the same item.

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Endnote

[1] Data on Australia, Czech Republic, Japan, the Netherlands and USA were cited from Teaching Science in Five Countries: Results from the TIMSS 1999 Video Study released in 2006.

[2] TIMSS item: What is the highest level of formal education that you have completed?
TIMSS modified item: What is the level(s) of formal education that you have completed?

[3] TIMSS item: Counting this year, how many years in total have you been teaching?

[4] TIMSS item: Counting this year, how many years in total have you taught science?

[5] TIMSS item: During the last two years have you participated in professional development activities or taken courses in any of the following? (Circle all letters that apply)
TIMSS modified item: Have you participated in professional development activities or taken courses, since you started teaching in any of the following? Kindly indicate the number of times and the year(s) you participated.

[6] TIMSS item: Participants were asked to write down the number of hours they spend on different school activities in a typical week.

[7] TIMSS item: Please describe the main thing you would like students to learn from this lesson.
TIMSS modified item: What were the main things you wanted students to learn from this lesson?