Chapter

A Comparative Study of Groups of Teachers on the Perceived Nature of Effective Teaching and Learning Science

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Abstract

The teacher is influential in the processes of teaching and learning science, organizing instruction to transform concepts into the understanding of students. Hence, teacher effectiveness is discussed in most educational forums as stakeholders look for more plausible ways of effective teaching and learning. As part of a large study on teachers' conception of an effective science teacher, we studied comparative views of mentors, mentees, and supervisors on the perceived nature of effective science teachers in the processes of teaching and learning science in basic schools. In a triangulation mixed methods design, 271 mentees, 160 mentors, and 85 supervisors were selected through multistage sampling procedures to respond to Effective Science Teacher Questionnaire and Interview Schedule. The data from the questionnaires were reduced to three factors through exploratory factor analysis. The qualitative data were analyzed thematically in line with the three factors. It was revealed that there was no statistically significant difference as supervisors differed not in their perceived nature of an effective science teacher compared to that of mentors and mentees. The Ministry of Education through the Ghana Education Service should provide opportunities for the three groups of teachers to share experiences on effective teaching and learning science in basic schools.

Keywords: effective teaching and learning, mentees, mentors, science, supervisors, and teachers

1. Introduction

Science educators, researchers, and stakeholders of science education among others have over decades agreed that the role of the [science] teacher in the classroom cannot be underestimated [1–6]. The role of the science teacher like any other teacher is to guide students to learn [1, 7]. However, this guidance (teaching) transcends just having a bunch of activities in the classroom [8]. It, thus, leaves science educators and researchers raising legions of questions including what is considered science teaching?

Is there anything that militates against the teaching process without which it cannot be considered science teaching? What does an analysis of the concept of teaching contribute to an appropriate conception of teaching science? [9]. For Ref. [10], the questions to be asked should be: what is science teaching about and who is an effective science teacher?

Across many disciplines, Ref. [11] looked at teaching as a social process that involves the teacher communicating and interacting with students focusing on helping the students develop their cognitive, affective, and psychomotor domains. It involves the teacher giving directions, asking questions and accepting or rejecting responses [11]. It is, also, seen as a scholarly activity, involving collecting experiences and critical thinking [12]. The teaching process involves guiding students to acquire higher knowledge or skills [13]. In the context of science education, effective science teaching is an art involving creativity, imagination, and innovation, along with planning, practice, decision-making, and evaluation.

Studies on effective [science] teachers and effective science teaching date over decades [3, 7, 14–17]. The literature also refers to effective teachers as good teachers [18, 19] and exemplary teachers [6]. Despite decades of studies, the puzzle of who an effective teacher is yet to be resolved [20–22]. It is noted that effective [science] teaching is difficult to describe [20, 21, 23] because it is multidimensional, highly individualized, and not always observed except only by students [21, 24]. Hence, the purpose of this research was to compare the views of three groups of teachers on the perceived nature of effective teaching and learning science in basic schools. To achieve this purpose, the following research question was crafted as a guide in this research:

How do supervisors' (college tutors') views on the perceived nature of effective teaching and learning science differ from that of mentors (in-service teachers in basic schools) and mentees (preservice teachers in colleges of education)?

To answer this research question, we explored the perceived nature of effective teaching and learning science from the three groups of teachers and the factors accounting for this perceived nature of effective teaching and learning science in basic schools. Finally, we examined whether there was a difference in how supervisors viewed the perceived nature of effective teaching and learning science in basic schools from that of mentors and mentees.

1.1 An effective teacher

In contemporary times, there is no widely accepted agreement about what exactly effective teaching is and how it should be measured [20]. Borich [20] explained that in the past an effective teacher was regarded as a good person and a role model who met community ideals for a good citizen, good parent, and good employee. Explaining further, Borich [20] noted that effective teacher was identified on the basis of their goodness as people with little attention to the teacher's classroom behavior and impact. Identifying teachers on this basis is untenable [15, 20]. Thus, in the past three decades, Borich [20] asserted that there is now a shift in this definition of an effective teacher with the focus being on teacher behavior and impact on students rather than their best.

Effective [science] teachers may be regarded as those who instill life-long learning habits in their students [25]. They share some common features regardless of their different teaching styles, disciplines (chemistry, physics, and biology), and backgrounds [25]. For Goe and Stickler [23], teacher effectiveness is a value-added

assessment of the degree to which in-service teachers contribute to their student's learning, as indicated by higher-than-predicted increases in student achievement scores. Again, in contemporary studies, the effective teacher is described as one who does things right, that is they plan their lesson, prepare the learning environment, conduct proper lesson introductions, ask questions, and use instructional material [26]. Simply, in any field of study, effectiveness is the ability to produce the desired outcome [5].

Walker [27] identified 12 characteristics of effective teachers needed for students to behave appropriately and acquire information. These features are preparation, a positive attitude, high expectations, creativity, fairness, personal touch, developing a sense of belonging, accepting mistakes, a sense of humor, respect for students, a forgiving attitude, and compassion. Bransford et al. [28] noted that effective teachers do not only appreciate what students everywhere can agree that teaching is not just talking and learning is not just listening [8] but they can figure out in one breathe what they want to teach and in another breathe doing it in a way that students can comprehend and utilize the knowledge and skills acquired.

1.2 An effective science teacher

In the context of science teaching, what does the literature say about effective science teachers? Effective science teachers are persons who combine teaching skills with an active belief that instruction can make a difference in science learning [15]. Ginns and Watters [29] pointed out that the starting point for examining the attributes of an effective teacher of science is to assess the nature of a preservice teacher education program and the expectations implicit in that program. However, contemporary ideas about the teaching of science suggest that the effectiveness of classroom science teaching may be investigated using an analytical framework that takes into account the initial teachers' preparation, and implementation of lessons and the classroom learning environment established by the teacher [29]. Those frameworks may include examining the characteristics that effective teachers possess. Fitzgerald et al. [24] reported that effective science teaching is essential in changing students learning outcomes positively and that there is a need to extract the components of effective science teaching to get a better comprehension of their work in the classroom and why they do what they do.

Teachers' characteristics in science education have been studied under these areas: knowledge of science content and instructional pedagogy, learning environment, interest in students' academic improvement, instructional materials, advanced preparation, and time management [6, 14, 25, 30, 31]. For instance, Stronge [31] categorized the teacher characteristics into six ways: the teacher as a person, classroom management and organization, organizing and orienting for instruction, implementing instruction, monitoring student progress and potential, and professionalism. Cherif [25] asserted that in the perspective of literature, the characteristics of an effective science teacher can be categorized as understanding; explaining that this encompasses understanding the subject matter, student's needs and the various teaching models and evaluation techniques, and the learning environment; teaching philosophies and approaches; stating clear objectives and practical methods; management; evaluation philosophies and technique; professionalism; demonstrating equity, quality, and diversity; and teaching beyond the classroom.

In addition, Cimer [7] concluded from a review of literature that effective teachers deal with students' prior ideas and conceptions, encourage students to

apply new knowledge in diverse contexts, encourage students to take part in lessons, encourage student inquiry, encourage cooperative learning among students, and offer continuous science. That is, effective science teachers utilize effective managerial practices, use strategies and activities that enable students, encourage student engagement in learning tasks, and maintain a favorable classroom environment [6].

1.2.1 Content knowledge of an effective science teacher

Among the various characteristics of effective science teachers so categorized in literature, knowledge of content and pedagogy (otherwise termed knowledge-based teaching) [32, 33] has been regarded as an integral part of effective teaching. Ababio [1] espoused that content knowledge is the subject matter, ideas, skills, or substance of what is taught. The three key areas advanced by Ababio [1] in relation to content, knowledge encompasses the teacher's familiarity with current knowledge in their subject area; the history and philosophy of teaching the subject; how the knowledge base of the subject informs or is formed by other disciplines; the teacher's knowledge and understanding of the different fields in their subject area (that is, the broad view of the subject in all its aspects); a firm understanding of its concepts, principles, values, theories, and generalizations; and having an unending enthusiasm for its study. Grant and Gradwell [34] referred to this enthusiasm as a teacher being ambitious, explaining that the teacher must have a good depth of understanding of the subject matter and effortlessly strive to connect it to students' experience.

From Ref. [1] three key areas, the teacher's content knowledge should be in-depth and must know the probable sources of knowledge in his/her subject from textbooks, journals, national dailies, and unpublished materials from where he/she should tap his/her content. According to Bransford et al. [28], content knowledge encompasses knowledge of learners and how they learn and develop within social contexts; knowledge of subject matter and curriculum goals; knowledge of teaching, such as subject matter, diverse learners, use of assessment; and classroom management.

A science teacher's knowledge has been found to be much more useful to students when it is combined appropriately with pedagogy [32, 35]. This pedagogy implies the whole philosophy and value system that leads teachers to make the choices they do in what and how to teach [16]. Cherif [25] opined that in the entire life of the effective teacher's career, he or she continues to develop the horizon of knowledge and understanding in their field of study and that he or she understands that it is one thing knowing how to teach and another having the content knowledge.

1.2.2 Assessment practices as a measure of an effective science teacher

Another characteristic of an effective science teacher is the attention paid to assessing students and providing feedback [19]. According to Zango et al. [19], effective teachers enable students to track their own performances, grade their homework, give oral and written feedback to students, document student progress and achievement, make instructional decisions based on student achievement data analysis, circulate in the room to assist students and provide praise, give pretests and graphs results, consider multiple assessments to determine whether a student has mastered a

skill, use student intervention plans and maintains records of the plans' implementation, record team conference or teacher conference with students, give assessments on a regular basis, vary instruction based on assessment analysis, exercise testing accommodations for special-needs of students, and maintain copies of all correspondences concerning student progress.

1.2.3 Classroom management as a measure of effective science teacher

Effective teachers are also known to be good managers of time for teaching and learning and student behavior so as to maximize learning [36, 37] and as well consider how students learn best [38]. Teachers manage the teaching and learning sessions so that there is minimum wastage of class time and high levels of engagement [37]. According to Woolnough [37], effective teachers monitor their classrooms by anticipating disruptive behaviors as well as checking on student engagement by moving around the classroom during small group work. For Zango et al. [19], an effective teacher's plan for the environment, both the organization of the classroom and of students, allows the classroom to run itself during student-teacher interaction; positions chairs in groups or around tables to promote interaction; manages classroom procedures to facilitate smooth transitions; manages student behavior through clear expectations and firm and consistent responses to student actions; maintains a physical environment where instructional materials and equipment are in good repair; covers walls with student work, student made signs, memos, and calendars of student events; emphasizes students addressing one another in a positive and respectful manner; and encourages interactions and allows low hum of conversations about activities or tasks. Also, an effective teacher maximizes the physical aspect of the environment, manages emergency situations as they occur, maintains acceptable personal workspace, establishes routines for the running of the classroom and the handling of routine student behavior, disciplines students with dignity and respect, shows evidence of established student routines for responsibilities and student leadership, exhibits consistency in management style, posts classroom and school rules, and posts appropriate safety procedures. According to Cherif [25], effective teachers ensure there is a welcoming environment that fosters positive relationships among students regardless of disparities in ethnic background, gender, social class, handicap, or prior academic achievement. Tobin and Fraser [6] reported that effective science teachers actively monitored student behavior in their classes by moving around the room and speaking with individuals from time to time, but they also maintain classroom discipline at a distance over the entire class.

1.2.4 Instructional strategies as a measure of an effective science teacher

Clarity of lesson, as well as the use of varied instructional strategies in delivery, has also been found to be a feature of effective [science] teachers [20]. That is, according to Borich [20], being clear in a lesson implies communicating lesson objectives to learners (describing what behaviors will be tested or required on future assignments as a result of the lesson); giving learners advance organizers; giving instructions patiently and uniquely; and using examples, illustrations, and demonstrations to explain and clarify. Consequently, instructional variability is about how the teacher is flexible in delivering the lesson. Instructional variety is also about using supporting instructional resources, such as computer software,

Using variety (an effective teacher)	Examples of teaching strategies
a. Uses attention-gaining devices (for example, begins with a challenging question, visual, and example)	a. Begin the lesson with an activity in a modality that is different from the last lesson or activity (for example, change from listening to seeing)
b. Shows enthusiasm and animation through variation in eye contact, voice, and gestures (for example, changes pitch and volume and moves about during the transition to a new activity)	b. Change position at regular intervals (for example, every 10 minutes change speed or volume to indicate that a change in content or activity has occurred)
c. Varies modes of presentation (for example, presents and asks questions and then provides for independent practice)	c. Establish an order of daily activities that rotate cycles of seeing, listening, and doing
d. Uses a mix of rewards and reinforcers (for example, extra credit, verbal praise, and independent study)	d. Establish lists of rewards and expressions of verbal praise and choose among them randomly. Provide reasons for praise along with the expression of it
e. Incorporates student ideas or participation in some aspects of instruction (for example, uses indirect instruction or divergent questioning)	e. Occasionally plan instruction in which student opinions are used to begin the lesson
f. Varies types of questions (for example, divergent and convergent)	f. Match questions to the behavior and complexity of the lesson objectives. Vary the complexity of the lesson objectives in accordance with the unit plan.

Table 1.
Indicators of instructional variety and corresponding instructional strategies [20].

displays, the internet, and space in your classroom [20]. Hence, the "physical texture and visual variety of the classroom" also form part of the instructional variety ([20], p. 8). **Table 1** shows the indicators and instructional strategies effective teachers use.

Moreover, questioning has been found to be the hallmark of effective teachers [20, 37]. According to Woolnough [37], effective teachers encouraged students to raise questions and respond to them without making the students feel stupid. Thus, the effective teacher needs to know the art of asking questions and how to use the different questioning as: fact questions, process questions, convergent questions, and divergent questions [20]. Effective teachers, check on students' developing understanding by questioning and inviting questions from the students [37]. According to Tobin and Fraser [6], effective teachers use questioning as a form of verbal strategy to stimulate thinking and to probe student responses for clarification and elaboration.

1.3 Empirical views an effective teaching and learning

In an exploratory study conducted by Lumpkin and Multon [21] using 69 male and 30 female teaching fellows (recognized as effective teachers) reported that these effective teachers used various instructional strategies to convey course content to students and enhance their learning. Moreover, in analyzing the profile of effective college and university teachers, Young and Shaw [10] noted that effective teachers are rated very high because of their genuine respect for students, concern for student learning, and value of the course. Also, effective teachers are not necessarily effective in all aspects but they can have some deficiencies. However, an effective teacher can

compensate for deficiencies in one or two areas by demonstrating outstanding skills in other areas.

In examining the profile of effective teachers in Greece, Koutrouba [39] concluded that many of the Greek secondary school teachers increased teaching effectiveness with their involvement of students in multimodal learning procedures, using communication techniques that helped to disseminate knowledge in a simpler, more understandable, individualized, and participatory way. Also, one thing that contributes to the effectiveness of the Greek teachers was their swift response to student needs during instruction, and they considered the classroom not as a technical workshop but as a place where human characters are being built. Greek teachers appeared to believe that a teacher's ability to satisfactorily ensure productive classroom management is an important feature of the effective educator, probably because "effective" does not, in any way, means unjustifiably soft and too pliant, but on the contrary, steady and objective during demanding. In addition, Greek teachers perceive cared about students' prior knowledge, simplifying the provided learning material in ways that meet individualized needs and respecting a diversity of any kind, ensuring solidarity and implementing democratic procedures, reducing students' learning load, and encouraging feedback, tend to be considered as effective teacher characteristics [39].

In analyzing the instructional practices of more versus less effective US teachers, Haynie and Stephani [4] reported that the most effective teachers have a more complete package of rigor, relevance, and relationship strategies than less effective teachers. More so, effective teachers have strong content knowledge, prepared their own materials, taught reading and note-taking skills, use time wisely, recognize the need to have a good relationship with the students, give frequent positive feedback, and believe that all students could succeed, create an atmosphere of mutual respect, in which both teachers and students are enthusiastic [4].

In Ghana, in a study involving pre-service teachers, Boadu [2] found out that the preservice teachers perceived effective teaching as comprising the acquisition of content knowledge, knowledge of learners, adequate planning, and collaboration with other teachers. In a related study in science, Adu-Gyamfi [14] examined 100 pre-service students on how they conceptualize who an effective science teacher is and reported that the pre-service teachers conceptualized an effective teacher in six ways. In these six ways, pre-service teachers conceptualize effective teachers to create an enabling learning environment suitable for teaching and learning, select and use appropriate teaching-learning materials, use appropriate teaching approaches and techniques, be mindful of what is expected of them as professionals, be interested in students' academic success, and have adequate content knowledge as well as instructional approaches.

Again, empirical study has shown that teacher preparation has a correlation with effective [science] teaching [40]. Because teacher preparation gives teachers knowledge, skill, and ability that are essential to their professional life [40]. Also, "teacher training molds the personality of teachers such that their attitudes are reshaped, their habits are reformed, and their personality is reconstituted through teachers training" ([40], p. 151). There are two types of teacher preparation: preservice training (training provided before employment of teachers and is generally required for employment) and in-service training (ongoing training teachers receive continuously throughout the educational life of a teacher). In assessing 80 participants to determine the relationship between teacher preparation and teacher effectiveness, Rahman et al. [40] reported that teachers had a positive attitude toward teacher training and its effectiveness in a classroom situation, such as actual instruction or academic work,

classroom management, evaluation procedures, assignments, and developing human relationships with students, principal, and society in general. This relationship should be positive. Similarly, Druva and Anderson [3] found a relationship between teacher preparation programs and what their graduates do as teachers and noted that science courses, education courses, and overall academic performance are positively correlated with successful teaching. In this regard, Cimer [7] recommended that college science teachers (supervisors) should prepare preservice [mentee] teachers to develop appropriate knowledge, strategies, and techniques relevant to creating an enabling environment for learning science. Skamp and Mueller [41] in a longitudinal study of preservice teachers' conceptions of effective primary science teaching noted that preservice teachers' conceptions of good science teaching do influence their practice and indicated it is problematic. Thus, teacher educators need to be aware that many conceptions held on entry to preservice education may be retained despite methodology units and practicum experiences.

According to McKnight et al. [5], nations worldwide recognize that to obtain improvement and equity in educational outcomes, attention should be directed toward teacher effectiveness and a primary way of achieving this is for individual countries to identify the competencies required for effectiveness and take that as the basis for developing teaching standards, preservice teacher preparation, professional development programs, and performance evaluations. More so, for an impact to be made, those systems and processes will need to be based on common comprehension, within each country, of what it means to be an effective teacher [5]. To this far, making a comparative analysis of what college teachers (supervisors), in-service teachers (mentors), and preservice teachers (mentees) perspectives of effective teaching and learning science will be one of the best ways to contribute to the development of teaching standards for effective delivery of science lessons in basic schools in Ghana.

2. Research methods

2.1 Research design

This research was structured and executed along the procedures of triangulation mixed methods design. This was necessary as we intended to compare the quantitative results on effective teaching and learning science in basic schools to qualitative results. This helped to validate the quantitative results with the qualitative results in order to understand the views of supervisors, mentors, and mentees on the perceived nature of effective teaching and learning science in basic schools.

In this triangulation mixed methods, we intended to collect as much qualitative data from teachers as possible, collecting both qualitative and quantitative data at the same time. The quantitative data on effective teaching and learning science were analyzed separately from the qualitative data. Thereafter, the two results were compared to establish any convergence or divergence in the views of teachers on effective teaching and learning based on the five-point Likert scale questionnaire and interview schedule employed in the data collection.

2.2 Sample and sampling procedures

The colleges of education in Ghana were mandated to prepare preservice teachers for basic schools (comprising primary and junior high schools). Initially, the colleges

of education awarded diplomas in basic education to graduating preservice teachers but since 2018 they have been mandated to award bachelor of education. To achieve this mandate, there were 46 public colleges and four private colleges of education spread across the 16 regions of Ghana involved as accredited institutions. The preservice teachers and their tutors, as well as the in-service teachers in their partner schools, in the 46 public colleges of education were the target population for this research. The 46 public colleges of education were mentored by the University of Ghana (six colleges), University for Development Studies (six colleges), University of Cape Coast (14 colleges), University of Education, Winneba (15 colleges), and Kwame Nkrumah University of Science and Technology (five colleges). The private colleges were as well mentored by some of the leading universities.

The 46 public colleges of education were classified into science colleges and non-science colleges. That is, there were some colleges of education that did not offer preservice teachers the sciences (as chemistry, biology, and physics) as major courses. Of the 46 public colleges of education, 12 were science colleges where preservice teachers pursued science as a major field of study. It was estimated that there were 96 science tutors in the 12 colleges who were selected by the census for this research. Per the best practices of the colleges, preservice teachers were assigned in a group of four members to each partner school of practice. Hence, there was one expected science mentee in 410 schools, where 300 were simply randomly selected together with their mentors to participate in this research. However, 85 science tutors (supervisors), 160 in-service teachers (mentors), and 271 preservice teachers (mentees) gave a total of 516 teachers who participated in the research by responding to the questionnaire. Of the 516 teachers, only 28 supervisors, 54 mentors, and 71 mentees participated in the interviews. Because most of the teachers gave reasons for engagement elsewhere and that they cannot be ready for the interviews at the scheduled times. The 153 teachers interviewed represented approximately 30.0% of the teachers who responded to the questionnaire.

2.3 Data collection instruments

There are two instruments used in this research to collect both quantitative and qualitative data to explore the perceived nature of effective teaching and learning science in order to compare the views of three teacher groups linked to colleges of education in Ghana [42]. The instruments were Effective Science Teacher Questionnaire and Effective Science Teacher Interview Schedule.

2.3.1 Effective science teacher questionnaire [ESTQ]

ESTQ was designed and developed by the researchers based on the findings of Adu-Gyamfi [14]. ESTQ had two sections. Section A comprised four items on teacher background information, such as the zone of college, sex of the teacher, level of teaching, and role of teachers. Section B comprised 69 items on the perceived nature of effective teaching and learning science. The items relating to the perceived nature of effective teaching and learning science were measured on a five-point Likert scale, ranging from a lower level of agreement of one to a higher level of agreement of five (Appendix A). To measure the internal consistency of ESTQ, it was pilot-tested with 10 science teachers outside the research zone. Thereafter, Cronbach's alpha coefficient of reliability was calculated. As the calculated value of Cronbach's alpha coefficient of reliability was *.94*, ESTQ was considered reliable, and none of the items was dropped.

2.3.2 Effective science teacher interview schedule [ESTIS]

ESTIS was designed and developed by the researchers with the intent of triangulating the findings from ESTQ. There were nine items grouped under Sections A and B. Section A had three items measuring the demographics of the teachers and six items in Section B measuring the views of teachers on effective teaching and learning science along instructional strategies, instructional materials, management of instructional time, academic improvement of students, teacher knowledge of content and pedagogy, and learning environment. Under each construct, there were carefully selected prompts to guide the interactions between interviewers and teachers (Appendix B). ESTIS was also designed along the lines of ESTQ and the findings of Adu-Gyamfi [14]. The validity of ESTIS was further achieved through honesty, depth, and richness of qualitative data collected on effective teaching and learning science from the three teacher groups. That is, teachers' views were reported as they were in detail for our audience to make their own judgment. Also, large data will be presented to support any induction leading to qualitative results on effective teaching and learning science. In addition, ESTIS was pilot-tested with 10 teachers and data were analyzed through thematic analysis. The themes were shared with teachers who participated in the pilot test for them to query how their views were used. This approach was repeated in the presentation of results in this chapter. That is, we shared the qualitative results with teachers who were interviewed prior to reporting them here.

2.4 Data collection procedures

The researchers visited the 12 colleges of education and discussed with college science tutors (supervisors) our intent to study effective teaching and learning science with them, their level 300 preservice teachers (mentees), and the mentors in the partner schools [42]. The three teacher groups were happy and prepared to contribute to the research though not all agreed to be interviewed. We used 4 weeks to collect both quantitative and qualitative data on effective teaching and learning science from teachers. ESTQ was first administered to teachers followed by interviews using ESTIS. That is, in each college researchers had first interactions with supervisors followed by mentees and mentors. There were instances the interviews were held immediately after the administration of ESTQ but for others, it took a day or two as we needed to schedule dates of convenience with teachers who were engaged as a result of their tight schedules. The interactions between researchers and teachers using ESTIS were audio-recorded.

2.5 Data processing and analysis

The data from ESTQ were checked to see that teachers had responded to all items. Thereafter, the five-point Likert scale was coded as 1 for a lower level of agreement, 2 for low agreement, 3 for moderate agreement, 4 for high agreement, and 5 for higher agreement. An exploratory factor analysis was used to reduce large data to factors. Multivariate ANOVA was used to examine whether differences existed among supervisors, mentors, and mentees on the factors established as the perceived nature of effective teaching and learning science.

The audio recordings were transcribed and cleaned. Thereafter, the qualitative data on effective teaching and learning science were open-coded and constantly compared using the factors generated from the exploratory factors analysis as the

main themes. We made sense of the views of teachers and compared them as coming from supervisors, mentors, and mentees. Sample views and codes of supervisors (such as S001 for supervisor 1), mentors (such as MR001 for mentor 1), and mentees (such as ME001 for preservice teacher 1) were provided to support any induction made on the themes.

3. Results

3.1 Perceived nature of effective teaching and learning science

The research question, in part, explored how the three groups of teachers perceived the nature of effective teaching and learning science in the basic school. To study this, ESTQ was administered to 516 teachers and their mean perceptions are tabulated in **Table 2**. The results showed the perceptions of supervisors, mentors, and mentees leading to the perceived nature of effective teaching and learning science among the teachers. The selected teachers had a highly positive perception of effective teaching and learning science in basic schools. That is, all supervisors, mentors, and mentees highly agreed to effective teaching and learning science (N = *521*, M = *4.25*, and Std. = *1.013*). For instance, under Items 1–11, the results showed that a science teacher was considered effective when his or her teaching in the classroom was geared toward using alternative instructional strategies to support student learning science concepts (Items 1 and 2). Of the 521 teachers, 351 (Item 3, *67.4%*, M = *4.44*, Std. = *.971*) highly perceived that an effective teaching and learning science involved a teacher reviewing the previous knowledge of the learner and choosing activity-based strategies (Item 4, *54.7%*, M = *4.22*, Std. = *1.070*) rather than an expository strategy (Item 5, *16.9%*, M = *2.56*, Std. = *1.508*). The selected teachers, also, highly perceived the instructional strategies of an effective science teacher as being practical and collaborative in nature (Item 6, *65.3%*, M = *4.41*, Std. = *.976*), and the instruction was moderately perceived as often carried out in laboratories (Item 8, *20.5%*, M = *3.07*, Std. = *1.467*) rather than relying on textbooks. In addition, the instructional strategies of an effective science teacher were perceived as teachers used of strategies that enable students to learn by applying knowledge acquired to their life experiences (Item 9, *91%*, M = *4.22*, Std. = *1.065*) and by this, an effective science teacher used illustrations that were real life experiences (Item 10, *62.2%*, M = *4.35*, Std. = *1.065*) and varied the strategies (Item 11, *63.9%*, M = *4.37*, Std. = *1.043*) to aid teaching and learning science in basic schools. Thus, there is a generally high positive perception of effective teaching and learning science that is aided by instructional strategies used by teachers to create opportunities for students learning, perhaps one that lends itself to the constructivist approach.

Again, from **Table 2**, the results showed that an effective teaching and learning science was considered by the majority of the selected teachers to be one where teachers used instructional materials in teaching to aid student learning of science concepts (Items 12–17). For instance, an effective teacher used more than one of those instructional materials in science lessons (Item 12, *56.6%*, M = *4.32*, Std. = *.0942*) made sure the resources were available before the start of the lesson (Item 13, *63.5%*, M = *4.40*, Std. = *.951*), was good in improvising instructional materials where necessary (Item 14, *53.2%*, M = *4.26*, Std. = *.991*), employed multiples teaching and learning resource for explaining the same concepts (Item 15, *50.3%*, M = *4.19*, Std. = *1.021*), used the instructional materials to arouse students' interest in learning (Item 17,

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
1.	An effective science teacher selects and uses instructional strategies	19	3.6	35	6.7	38	7.3	134	25.7	295	56.6	4.25	1.084
2.	An effective science teacher studies the curriculum to guide their choice of appropriate teaching method	7	1.3	34	6.5	33	6.3	96	18.4	351	67.4	4.44	.963
3.	An effective science teacher often reviews students' relevant previous knowledge and builds on them	10	1.9	29	5.6	34	6.5	97	18.6	351	67.4	4.44	.971
4.	An effective science teacher uses activity-based methods of teaching	18	3.5	29	5.6	58	11.1	131	25.1	285	54.7	4.22	1.070
5.	An effective science teacher uses a lecture method of teaching	191	36.7	94	18.0	76	14.6	72	13.8	88	16.9	2.56	1.508
6.	An effective science teacher uses methods that make his/her lessons practical and collaborative/ participatory	11	2.1	24	4.6	47	9.0	99	19.0	340	65.3	4.41	.976
7.	An effective science teacher teaches science through practical works that are laboratory-based to enhance student understanding	14	2.7	41	7.9	64	12.3	109	20.9	293	56.2	4.20	1.097
8.	An effective science teacher relies on textbooks to teach science	97	18.6	108	20.7	107	20.5	91	17.5	115	22.1	3.07	1.467
9.	An effective science teacher teaches scientific concepts and ideas using a methodology that aids the application of the knowledge to everyday life experiences	16	3.1	31	6.0	61	11.7	127	24.4	286	54.9	4.22	1.065
10.	An effective science teacher is a teacher who uses real-life illustrations to explain various scientific concepts	13	2.5	28	5.4	49	9.4	107	20.5	324	62.2	4.35	1.019
11.	An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students	18	3.5	27	5.2	33	6.3	110	21.1	333	63.9	4.37	1.043
12.	An effective teacher uses more than one teaching and learning material	9	1.7	18	3.5	66	12.7	133	25.5	295	56.6	4.32	.942
13.	Effective science teacher ensures that their teaching resources are available before they start their lessons	9	1.7	21	4.0	56	10.7	104	20.0	331	63.5	4.40	.951
14.	An effective science teacher is good at improvisation of teaching and learning materials	15	2.9	17	3.3	65	12.5	147	28.2	277	53.2	4.26	.991
15.	An effective science teacher uses multiple teaching and learning materials for the explanation of the same concept	16	3.1	20	3.8	75	14.4	148	28.4	262	50.3	4.19	1.021

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Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
16.	An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas	7	1.3	20	3.8	58	11.1	138	26.5	298	57.2	4.34	.917
17.	An effective science teacher employs teaching and learning materials that arouse the desire of learners to learn	7	1.3	25	4.8	53	10.2	118	22.6	318	61.0	4.37	.942
18.	An effective science teacher prepares in advance before coming to class	13	2.5	18	3.5	48	9.2	96	18.4	346	66.4	4.43	.968
19.	An effective teacher is confident because he prepares well in advance to produce higher student achievements	12	2.3	18	3.5	52	10.0	108	20.7	331	63.5	4.40	.962
20.	An effective science teacher is someone who tries as much as possible to find something in the community, within his busy schedule, to relate every topic for easy student understanding	8	1.5	21	4.0	73	14.0	142	27.3	277	53.2	4.26	.950
21.	An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessments	15	2.9	21	4.0	76	14.6	115	22.1	294	56.4	4.25	1.034
22.	An effective science teacher is creative in teaching science	12	2.3	26	5.0	59	11.3	125	24.0	299	57.4	4.29	1.005
23.	An effective science teacher is one who never misses his/her instructional hours	17	3.3	29	5.6	84	16.1	145	27.8	246	47.2	4.10	1.068
24.	An effective science teacher plans and teaches within the given instructional time	18	3.5	20	3.8	62	11.9	134	25.7	287	55.1	4.25	1.036
25.	An effective science teacher takes his/her time to teach without rushing through the presentation of lesson	14	2.7	19	3.6	44	8.4	123	23.6	321	61.6	4.38	.973
26.	During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students	13	2.5	28	5.4	54	10.4	112	21.5	314	60.3	4.32	1.024
27.	An effective science teacher is a teacher who will have time to explain to students' aspects of topics that are difficult to understand	14	2.7	12	2.3	53	10.2	124	23.8	318	61.0	4.38	.950
28.	An effective science teacher uses instructional time consciously to the benefit of students	13	2.5	25	4.8	52	10.0	152	29.2	279	53.6	4.26	.992
29.	An effective science teacher creates a conducive environment for students to learn scientific concepts and ideas	14	2.7	17	3.3	52	10.0	140	26.9	298	57.2	4.33	.969
30.	Effective science teachers' lessons are always interesting and enjoyable.	11	2.1	25	4.8	65	12.5	137	26.3	283	54.3	4.26	.992
31.	An effective science teacher always responds appropriately to questions students ask	12	2.3	17	3.3	57	10.9	134	25.7	301	57.8	4.33	.957

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
32.	An effective science teacher uses formative assessment to sustain students' interest in learning	23	4.4	18	3.5	60	11.5	138	26.5	282	54.1	4.22	1.069
33.	An effective science teacher has good human relationships between science teachers and students during science lessons	14	2.7	22	4.2	71	13.6	118	22.5	296	56.	4.27	1.023
34.	An effective science teacher loves and shows empathy for students	17	3.3	31	6.0	68	13.1	139	266	51.1		4.16	1.072
35.	An effective science teacher is an open-minded person creating room for constructive criticism	15	2.9	19	3.6	67	12.9	158	30.3	262	50.3	4.21	.996
36.	An effective science teacher motivates students to learn science	13	2.5	16	3.1	50	9.6	118	22.6	324	62.2	4.39	.957
37.	An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied	8	1.5	12	2.3	62	11.9	113	21.7	326	62.6	4.41	.897
38.	An effective science teacher guides students on how to search for answers to questions raised	14	2.7	20	3.8	64	12.3	160	30.7	263	50.5	4.22	.987
39.	An effective science teacher builds his/her students' confidence in the learning of the subject of science	14	2.7	13	2.5	69	13.2	121	23.2	304	58.3	4.32	.978
40.	An effective science teacher provides students with the experiences needed to learn science	12	2.3	17	3.3	59	11.3	139	26.7	294	56.4	4.32	.958
41.	An effective science teacher has good class control	10	1.9	22	4.2	55	10.6	114	21.9	320	61.4	4.37	.964
42.	An effective science teacher presents his/her lessons systematically and orderly	13	2.5	17	3.3	52	10.0	112	21.5	327	62.8	4.39	.966
43.	An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex	16	3.1	15	2.9	59	11.3	114	21.9	317	60.8	4.35	.998
44.	An effective science teacher ensures that everyone understands the first topic before moving to the next topic	15	2.9	29	5.6	75	14.4	127	24.4	275	52.8	4.19	1.059
45.	An effective science teacher gives a kind of exercise that will demand a lot of research for about a week	50	9.6	44	8.4	94	18.0	128	24.6	205	39.3	3.76	1.311
46.	An effective science teacher evaluates learners in science class	15	2.9	27	5.2	62	11.9	149	28.6	268	51.4	4.21	1.029
47.	An effective science teacher monitors learners in science class	9	1.7	29	5.6	66	12.7	135	25.9	282	54.1	4.25	.992
48.	An effective science teacher gives students enough work examples for them to practice	11	2.1	20	3.8	73	14.0	136	26.1	281	53.9	4.26	.979
49.	An effective science teacher always gives an assignment, to his/her students, marks, and discusses it so the students know their shortcomings for rectification	10	1.9	19	3.6	68	13.1	111	21.3	313	60.1	4.34	.968

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
50.	An effective science teacher distributes questions to all students in science lessons	17	3.3	15	2.9	69	13.2	130	25.0	290	55.7	4.27	1.014
51.	An effective science teacher uses simple vocabulary that can be understood by all students in a science lesson	16	3.1	19	3.6	46	8.8	110	21.1	330	63.3	4.38	1.001
52.	An effective science teacher communicates science terminologies very well to the understanding of students	15	2.9	15	2.9	60	11.5	130	25.0	301	57.8	4.32	.984
53.	An effective science teacher can be tolerant of all students' questions and issues in science lessons	20	3.8	22	4.2	70	13.4	144	27.6	265	50.9	4.17	1.063
54.	An effective science teacher responds swiftly to students' questions raised during lessons	14	2.7	32	6.1	97	18.6	143	27.4	235	45.1	4.06	1.060
55.	An effective science teacher provides students with opportunities to develop the knowledge, skills, and attitudes they need in the classroom.	8	1.5	18	3.5	63	12.1	114	21.9	318	61.0	4.37	.932
56.	An effective science teacher considers individual intellectual abilities in teaching scientific concepts and ideas to a class of students	12	2.3	23	4.4	74	14.2	146	28.0	266	51.1	4.21	.997
57.	An effective science teacher considers the academic level of students in teaching scientific concepts and ideas	11	2.1	17	3.3	67	12.9	134	25.7	292	56.0	4.30	.959
58.	An effective science teacher considers the level and stages of the students in order to know the techniques, strategies, and methods to use in teaching	11	2.1	20	3.8	56	10.7	132	25.3	302	58.0	4.33	.960
59.	An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science	11	2.1	21	4.0	70	13.4	138	26.5	281	53.9	4.26	.979
60.	An effective science teacher prepares students to perform creditably well in examinations.	10	1.9	21	4.0	66	12.7	137	26.3	287	55.1	4.29	.965
61.	An effective science teacher demonstrates sufficient knowledge of science to students	15	2.9	26	5.0	64	12.3	148	28.4	268	51.4	4.21	1.028
62.	An effective science teacher should have in-depth knowledge of the topic before teaching	1	0.2	15	2.9	25	4.8	57	10.9	115	22.1	4.29	1.048
63.	An effective science teacher is a teacher who justifies what he/she is teaching to the admiration of students	19	3.6	27	5.2	74	14.2	127	24.4	274	52.6	4.17	1.085
64.	An effective science teacher is abreast of the current state of scientific knowledge	10	1.9	26	5.0	68	13.1	131	25.1	285	54.7	4.26	.993
65.	An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles	13	2.5	17	3.3	68	13.1	113	21.7	310	59.5	4.32	.989

Item	Statement	LW		L		M		H		HH		M	Std.
		f	%	f	%	f	%	f	%	f	%		
66.	An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching	11	2.1	19	3.6	66	12.7	127	24.4	298	57.2	4.31	.970
67.	An effective science teacher can justify what he/she is teaching using the appropriate approach	7	1.3	13	2.5	63	12.1	123	23.6	315	59.1	4.39	.890
68.	An effective science teacher uses appropriate instructional strategies to present the content	13	2.5	12	2.3	52	10.0	135	25.9	308	59.1	4.37	.936
69.	An effective science teacher uses a variety of approaches to avoid boredom during science lessons	13	2.5	9	1.7	57	10.9	85	16.3	356	68.3	4.47	.936
	Overall											**4.25**	**1.013**

LW = Lower, L = Low, M = Moderate, H = high, HH = higher, SD = standard deviation, F = frequency, M = Mean.

Table 2.
Mean perceptions of teachers on the perceived nature of teaching and learning science (N = 516).

61.0%, M = *4.37*, Std. = *.942*), and aided students' comprehension of science concepts in basic schools (Item 16, *57.2%*, M = *4.34*, Std. = *.917*). Hence, supervisors, mentors, and mentees perceived positively that characteristically, and effective teaching and learning science involves teachers acquiring and appropriately using instructional materials for lesson delivery to aid learning science by students in basic schools.

The results under Items 18–28 of **Table 2** provided the image of effective teaching and learning science in terms of preparation and time management of teachers. For instance, the selected teachers highly perceived that an effective science teacher prepared in advance (Item 18, *66.4%*, M = *4.43,* Std. = *.968*) to ensure his or her confidence to produce higher students' achievement (Item 19, *63.5%*, M = *4.40*, Std. = *.962*). Also, the selected teachers highly perceived that creativity was needed in teaching and learning science (Item 22, *57.4%*, M = *4.29*, Std. = *1.005*) to make effective use of materials in the immediate environment to aid learning science concepts (Item 20, *53.2%*, M = *4.26*, Std. = *.950*). Besides the selected teachers perceived that an effective science teacher was punctual (Item 23, *47.2%*, M = *4.10*, Std. = *1.068*) making effective use of time in lesson delivery (Item 24, *55.1%*, M = *4.25*, Std. = *1.036*) to demonstrate science concepts and explain difficult parts of the concept (Items 26 and 27) and not misusing instructional hours (Items 28, *53.6%*, M = *4.25*, Std. = *.992*). Hence, all teachers (supervisors, mentors, and mentees) perceive that another nature of effective teaching and learning is related to advanced preparation and instructional time management in basic school science.

Moreover, the results showed that the selected teachers perceived that an effective teaching and learning science was a unique one and should be held in a conducive learning environment (Items 29–55). For instance, the majority of the selected teachers highly perceived an effective science teacher was one who created a conducive environment for students to learn (Item 29, *57.2%*, M = *4.33*, Std. = *.969*), leading to interesting lessons on science concepts (Item 30, *54.3%,* M = *4.26,* Std. = *.992*). Because students can ask questions and are responded to (Items 31, 53, and 54) establishing a good personal relationship with students and their teachers to foster learning science by students in basic schools (Items 33, 34, 35, 37, and 38). Thus, in creating a conducive learning environment, the selected teachers perceived that effective science teachers made attempts to motivate and inspire students to learn science (Items 36 and 39) and to assess students' learning (Items 32 and 45). Also, effective teaching and learning science demanded that lessons were presented by teachers systematically and sequenced from simple to complex with well-ordered concepts (Items 42, 43, and 44). Hence, the three groups of teachers perceive that another nature of effective teaching and learning science is teachers' creation of a conducive environment friendly to students' learning science in the basic schools.

Again, the results showed that the selected teachers perceived effective teaching and learning science as that of which teachers were interested in students' successes in their academics. Because under Items 56–60, teachers perceived that an effective science teacher considered the individual intellectual capability when teaching to aid students in learning science concepts (Items 56 and 57), allowing this to guide the selection of instructional strategies and resources (Item 58, *58.0%,* M = *4.33*, Std. = *.960*). Besides, the selected teachers highly perceived that an effective science teacher used instructional strategies and materials to create room for addressing student weaknesses in science concepts (Item 59, *53.9%,* M = *4.26,* Std. = *.979*) aiding students in preparation for examinations to perform creditably well (Item 60, *55.1%,* M = *4.29,* Std. = *.965*). Hence, characteristically, the three groups of teachers perceive that

effective teaching and learning science should be geared toward great interest in students' success.

Also, the results from **Table 2** showed that the selected teachers perceived effective teaching and learning science as one where teachers demonstrated adequate knowledge of content and instructional strategy. Because under Items 61–69, supervisors, mentors, and mentees perceived that an effective science teacher should have sufficient knowledge of science concepts (Items 61 and 62) through research to demonstrate detailed explanations of science concepts to basic school students (Items 65 and 66). More so, an effective science teacher was capable of transforming content knowledge using appropriate instructional strategies in science lessons (Items 68, *59.1%,* M = 4.37, Std. = *.936*) and being able to sustain students' interest (Item 69, *68.3%,* M = *4.47*, Std. = *.936*). Hence, the supervisors, mentors, and mentees perceive that another nature of effective teaching and learning science is demonstrated through teachers' knowledge of science content and instructional strategy.

3.2 Factors accounting for perceived nature of effective teaching and learning science

Having established the nature of effective teaching and learning as perceived by supervisors, mentors, and mentees, there was need to explore further the factors that accounted for this positive perception of the selected groups of teachers. In order to explore the factors that accounted for the teacher's perception of effective teaching and learning science, a principal component analysis (PCA) was conducted on the 69 items on ESTQ. To begin with, the Kaiser-Meyer-Olkin (KMO) measure was verified to be *.979* with Bartlett's test for sphericity (*34066.712*) being significant (p = *.000*, df = *2346*). With KMO above *.50* and Bartlett's test for sphericity being significant, factor analysis was conducted because none of the assuptions under factor analysis was violated [43–46]. Factor analysis was conducted with the 69 items and based on Kaiser Criterion of *1*, seven components were obtained with a cumulative explanation of variance being *67.8%.* The percentage variance of the seven components is presented in **Table 3**.

In order to ascertain if all components were worth retaining, the scree plot was examined. The results from the scree plot are presented in **Figure 1**.

From **Figure 1**, it is apparent that three components were worth retaining. Because according to Pallnt [45], when checking the scree plot to determine the factors to retain, one needs to look for the change in the shape of the plot and consider only components above it for retention. Thus, components 1, 2, and 3 were retained as the factors that accounted for the perceived nature of effective teaching and learning science. Aside from the three components being above the change in shape, they explained more (*60.1%* cumulative explanation) of the variance than the other components.

A parallel analysis (PA) was further run to ascertain if the three components were worth retaining [47]. The actual eigenvalues from the PCA were compared with the criterion values from the PA. A decision was made to accept eigenvalues of the PCA greater than the criterion value of the PA, and fewer values were rejected [45, 47, 48]. The results of the comparison of the PCA and PA are presented in **Table 4**.

The results from **Table 4** showed that only three factors were to be retained. Because only the three factors have their eigenvalues greater than the criterion values from the parallel analysis. Therefore, only three factors were retained for the determination of the selected teachers' perception of effective teaching and learning science in the basic school.

Component	Total	% of variance	Cumulative %
1	37.146	53.835	53.835
2	2.628	3.809	57.644
3	1.775	2.572	60.215
4	1.542	2.235	62.450
5	1.346	1.951	64.401
6	1.283	1.859	66.261
7	1.032	1.496	67.757

Table 3.
Percentage variance explained by the extracted components.

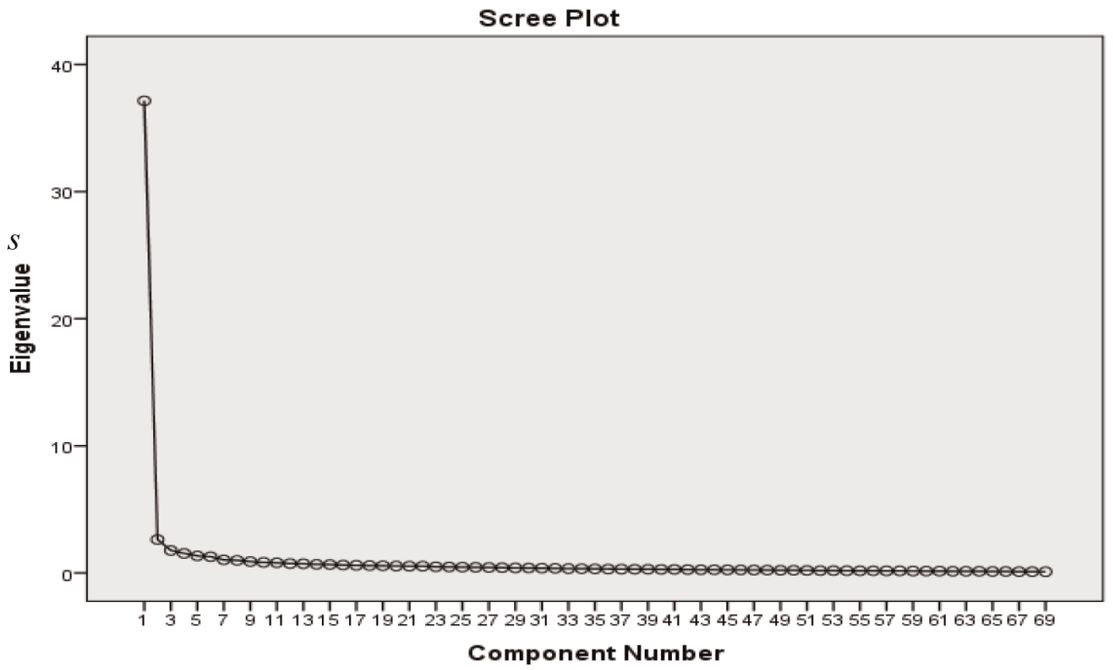

Figure 1.
An illustration of components of the perceived nature of effective teaching and learning science.

Component number	Actual eigenvalue from PCA	Criterion value from parallel analysis	Decision
1	37.146	1.798937	Accept
2	2.628	1.729698	Accept
3	1.775	1.681724	Accept
4	1.542	1.641841	Reject

Table 4.
Comparing eigenvalues from PCA to criterion values from PA on effective teaching and learning science.

The principal component analysis was conducted again with only the three factors. Inspection of the commonalities of the various items revealed some extremely low commonalities. Hence, items whose commonalities were below .6 [44, 46] were

deleted and a re-run of the PCA was conducted. Consequently, 36 items were re-run after the deletion of 28 items with low communalities and those 36 items gave a KMO value of *.975* and Bartlett's test for sphericity (*17625.684*) to be (df = *630*, ρ = *.000*). However, to make the data interpretable, varimax rotation was conducted [44–46]. For practical significance, a factor loading of *.7* or above for a sample size of 100 or more was appropriate [44], as it implied such factor loading accounted for more than 50.0% of the variance explained by a variable. Thus, in this research, factors that loaded above *.5* were considered. In the case of cross-loadings, only factors with higher loading under a particular component were considered [39]. From the varimax rotation as shown in **Table 5**, factor 1 explained *59.97%*, factor 2 explained *4.66%*, and factor 3 explained *2.75%*. However, the total variance explained remained almost the same *67.38%* as obtained from the initial analysis. The reliabilities of the factors were determined to be *.973* for factor 1, for factor 2, *.921*, for factor 3, *.932,* and the overall reliability was *.981*. The factor loadings together with the variance explained and Cronbach alpha of the components are shown in **Table 5**.

The three factors retained were conceptualized as a conducive learning environment (being teacher's knowledge of how to transform the content in a classroom that

Statement	Eigenvalues
An effective science teacher often reviews students' relevant previous knowledge and builds on them	.664
An effective science teacher uses methods that make his/her lessons practical, and collaborative/participatory	.749
An effective science teacher is a teacher who uses real-life illustrations to explain various scientific concepts	.740
An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students	.652
An effective teacher uses more than one teaching and learning materials	.647
An effective science teacher studies the curriculum to guide their choice of appropriate teaching method	.708
An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas	.497
An effective science teacher prepares in advance before coming to class	.638
An effective teacher is confident because he prepares well in advance to produce higher students achievements	.654
An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessment	.619
An effective science teacher is creative in teaching science	.650
During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students	.674
An effective science teacher is a teacher who will have time to explain to students aspects of topics that are difficult to understand	.626
An effective science teacher uses instructional time consciously to the benefit of students	.659
An effective science teacher has good human relationships between science teachers and students during science lessons	.626

Statement	Eigenvalues		
An effective science teacher loves and shows empathy for students	.691		
An effective science teacher motivates students to learn science	.574		
An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied,	.616		
An effective science teacher guides students on how to search for answers to questions raised	.732		
An effective science teacher builds his/her students' confidence in learning of the subject science	.671		
An effective science teacher provides students with experiences needed to learn science	.703		
An effective science teacher presents his/her lessons systematically and orderly	.630		
An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex	.529		
An effective science teacher gives students enough work examples for them to practice	.694		
An effective science teacher always gives an assignment, to his/her students, marks, and discusses it so the students know their shortcomings for rectification	.714		
An effective science teacher distributes questions to all students in science lessons	.759		
An effective science teacher uses simple vocabulary that can be understood by all students in a science lesson	.732		
An effective science teacher communicates science terminologies very well to the understanding of students	.677		
An effective science teacher can be tolerant of all students' questions and issues in science lessons	.727		
An effective science teacher provides students with opportunities to develop knowledge, skills, and attitudes they need in the classroom	.646		
An effective science teacher considers the level and stages of the students in order to know the techniques, strategies, and methods to use in teaching	.542		
An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science	.584		
An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles	.564		
An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching	.550		
An effective science teacher can justify what he/she is teaching using the appropriate approach	.527		
An effective science teacher uses appropriate instructional strategies to present the content	.602		
% variance explained	59.97	4.66	2.75
Cumulative % variance explained	67.38		
Cronbach alpha	.973	.921	.932
overall Cronbach alpha	.981		

Table 5.
Factors evolving from the component matrix on the perceived nature of effective science teachers by supervisors, mentors, and mentees.

is friendly enough to meet the learning needs of students), instructional processes (the steps taken by the teacher to support students make meaning of science concepts in the classroom), and consciousness of professional demands (being teacher awareness of what are expected of him or her and preparing to in advance to boost confidence to implement lessons within scheduled time) [14].

3.2.1 Conducive learning environment

This factor explained what effective science teachers do in the classroom as they attempt to transform their knowledge of the content to suit the learning needs of students in a friendly manner. The means of agreement of the groups of items under a conducive learning environment are presented in **Table 6**.

The results showed that the average mean of conducive learning environment was *4.32* (Std. = *.97*). This indicated that the selected teachers highly perceived conducive learning environment as nature of effective teaching and learning science in the basic school. To further understand this, all three groups of teachers were interviewed using ESTIS. From the analyzed interviews, the selected teachers viewed effective teaching and learning science as associated with the creation of a

Statement	M	Std.
An effective science teacher has good human relationships between science teachers and students during science lessons	4.27	1.023
An effective science teacher loves and shows empathy for students	4.16	1.072
An effective science teacher motivates students to learn science	4.39	.957
An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied,	4.41	.897
An effective science teacher guides students on how to search for answers to questions raised	4.22	.987
An effective science teacher builds his/her students' confidence in learning of the subject science	4.32	.978
An effective science teacher provides students with experiences needed to learn science	4.32	.958
An effective science teacher presents his/her lessons systematically and orderly	4.37	.964
An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex	4.39	.966
An effective science teacher gives students enough worked examples for them to practice	4.26	.979
An effective science teacher always gives an assignment, to his/her students, marks and discusses it so the students know their shortcomings for rectification	4.34	.968
An effective science teacher distributes questions to all students in science lessons	4.27	1.014
An effective science teacher uses simple vocabulary that can be understood by all students in a science lesson	4.38	1.001
An effective science teacher communicates science terminologies very well to the understanding of students	4.32	.984
An effective science teacher can be tolerant of all students' questions and issues in science lessons	4.17	1.063
An effective science teacher provides students with opportunities to develop knowledge, skills, and attitudes they need in the classroom.	4.37	.932

Statement	M	Std.
An effective science teacher considers level and stages of the students in order to know the techniques, strategies, and methods to use in teaching	4.33	.960
An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science	4.26	.979
An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles	4.32	.989
An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching	4.31	.970
An effective science teacher can justify what he/she is teaching using the appropriate approach	4.39	.890
An effective science teacher uses appropriate instructional strategies to present the content	4.37	.936
Overall	**4.32**	**0.97**

Table 6.
Mean agreements of teaching and learning science in conducive learning environment.

conducive learning environment to inspire students to learn science concepts. An excerpt is;

> *By creating a very conducive and good teacher-student relationship in order to arouse the interest of students during lessons. This eliminates fear from students and subsequently boosts learning* (ME006).

In a conducive learning environment, teachers motivated students to freely ask questions. Excerpts are;

> *Yes, because when there is a good relationship between teacher and students, a very conducive academic environment is created for students to willingly ask questions and teachers demonstrate their knowledge here* (ME050).

> *Yes, when there is a conducive environment and a good relationship between teacher and student, they are motivated to feel free and willing to ask questions during lessons. In this kind of environment, students feel the knowledge of their teacher* (S024).

Also, in a conducive learning environment, teachers demonstrated in-depth knowledge of the content of science to make students feel comfortable in learning. An excerpt is;

> *Should be well knowledgeable in scientific content and instructional strategies so as to know what they teach and to instill confidence in his/her students* (MR028).

3.2.2 Instructional processes

The instructional processes described effective teaching and learning science as encompassing all the steps taken by teachers to aid in the presentation of science concepts in lessons to the understanding of their students. **Table 7** shows the mean agreement on the perceived nature of effective teaching and learning science in relation to instructional processes.

Statement	M	Std.
An effective science teacher often reviews students' relevant previous knowledge and builds on them	4.44	.971
An effective science teacher uses methods that make his/her lessons practical and collaborative/participatory	4.41	.976
An effective science teacher is the teacher who uses real-life illustrations to explain various scientific concepts	4.35	1.019
An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students	4.37	1.043
An effective teacher uses more than one teaching and learning materials	4.32	.942
An effective science teacher studies the curriculum to guide their choice of appropriate teaching method	4.44	.963
An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas	4.34	.917
Overall	**4.38**	**.980**

Table 7.
Mean agreements of effective teaching and learning science in relation to instructional processes.

It can be deduced from **Table 7** that the selected teachers had a high positive perception (M = *4.38*, Std. = *.980*) of the instructional processes as a factor of effective teaching and learning. That is, all supervisors, mentors, and mentees perceived highly that instructional processes such as making science lessons practical and participatory (M = *4.41*, Std. = *.976*) through the use of multiple teaching and learning resources (M = *4.32*, Std. = *.942*), and selecting and using relevant resources in science lessons (M = *4.44*, Std. = *.963*) contributed to effective teaching and learning science in basic schools. Also, teachers taking steps to vary the instructional strategies in a lesson (M = *4.37*, Std. = *1.043*) and using real-life illustrations to explain concepts (M = *4.35*, Std. = *1.019*) were dimensions of instructional processes that contributed to effective teaching and learning science in basic schools.

To further understand issues relating to instructional processes, the outcomes of the interviews using ESTIS with supervisors, mentors, and mentees were analyzed under this theme. The three groups of teachers confirmed that effective teaching and learning science involved the use of participatory approaches in science lessons. Because the teachers interviewed were of the view that adopting steps to use group activities, demonstrations, hands-on activities, and other participatory instructions was key to effective teaching and learning science in basic schools. Excerpts are;

> *These participatory teaching methods are effective because learners are able to construct knowledge among themselves and this aids their understanding* (ME051).
>
> *The use of group activities helps involve everybody in the class including the weaker ones to make meaning with some ease* (MR055).
> *... because students learn well when they are made to actively participate through hands-on experiences (experiments)* (S021).

There appeared to be agreement on the viewpoint of the teachers interviewed that effective teaching and learning science involved selection and usage of more than

one instructional resource and that they either improvise these or go for realia. Excerpts are

> *They improvise or buy them from shops. Because teachers need variety to spice their teaching* (ME013).

> *Picking them from their locality is important but measures should be put in place by the science teacher to use more conventional materials. Because they enrich students' experiences* (MR001).

> *... purchase them from the market and also through the internet. Because to be effective, you will need the materials and then, adopt means as a teacher to help students in the classroom* (S028).

Teachers taking steps to use a variety of instructional resources in science lessons was made stronger as the teachers interviewed believed that the multiple uses of instructional materials aided students' comprehension of science concepts. Excerpts are;

> *To give students the experience of diversified ways of learning and solving problems using a number of materials in a single lesson is important* (S008).

> *... the more instructional materials used, the more in-depth knowledge and understanding they provide to students* (S021).

3.2.3 The consciousness of professional demands

Continuous professional development described a teacher's awareness of what was expected of him or her leading to preparation in advance to boost confidence in implementing lessons within the scheduled time. The mean agreement on the perceived nature of effective teaching and learning science in relation to the consciousness of professional demands is presented in **Table 8**.

As shown in **Table 8**, the selected teachers' highly perceived effective teaching and learning science was influenced by teacher consciousness of professional demands. Because all supervisors, mentors, and mentees highly agreed that teacher consciousness of professional demands (M = *.4.33,* Std. = *.991*) is one of the factors of effective teaching and learning science in basic schools. That is, effective science teachers prepared in advance prior to meeting students in science classrooms (M = *4.43*, Std. = *.968*) to boost their confidence in teaching (M = *4.40,* Std. = *.962*) leading to effective management of instructional time in teaching difficult science concepts (M = *4.38*, Std. = *.950*) to the benefit of students (M = *4.26*, Std. = *.992*).

To validate the factor and consciousness of professional demands as contributing to effective teaching and learning science, some selected supervisors, mentors, and mentees were interviewed with ESTIS. The outcomes of the interviews were analyzed with the consciousness of professional demands as one of the themes. From the viewpoint of the teachers interviewed, effective teaching and learning science should involve teachers making a conscious effort to meet the demands of their job, especially their interactions with students in the classroom. For instance, teachers interviewed mentioned that effective teaching and learning science involved teachers preparing well ahead to address any envisaged shortfalls to aid students in learning science concepts. Excerpts are;

Statement	M	Std.
An effective science teacher prepares in advance before coming to class	4.43	.968
An effective teacher is confident because he prepares well in advance to produce higher students achievements	4.40	.962
An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessments	4.25	1.034
An effective science teacher is creative in teaching science	4.29	1.005
During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students	4.32	1.024
An effective science teacher is a teacher who will have time to explain to students aspects of topics that are difficult to understand	4.38	.950
An effective science teacher uses instructional time consciously to the benefit of students	4.26	.992
Overall	**4.33**	**.991**

Table 8.
Mean agreements of effective teaching and learning science in relation to consciousness of professional demands.

> *... teachers prepare by planning and allocating a number of minutes that will be used at every stage of the lesson because when teachers prepare ahead, they can work around any problem that will hinder effective teaching* (S008).

> *... prepares by having proper planning on when and what to use. You see without preparing in advance the teacher will not see any problem ahead* (MR001).

Professionally, teachers teaching in basic schools needed to plan their lessons. That is, planning for effective teaching and learning science included their preparation of lesson notes. A well-planned lesson contributed to teachers' confidence in the process of teaching and learning science. Excerpts are:

> *Effective teaching is achieved through the preparation of lesson plans. This makes you a professional teacher from the nonprofessionals* (MR045).

> *... This makes the teacher confident to do a better explanation of scientific concepts without deviating* (ME005).

> *The demands of the lesson plan as professional teachers make lesson presentations effective, efficient, and good time managers* (MR013).

The teachers interviewed mentioned that, professionally, the essence of advanced preparation helped teachers to manage their time well. Excerpts are:

> *Yes, in order not to spend so much time, which will lead to waste of time, as a would-be professional teacher, I'm trained to plan for effective use of time during teaching* (ME028).
> *Time budgeting is an important aspect of a well-planned science lesson. Hence, to be effective in science lessons, I look forward to seeing how teacher trainees manage time during science lessons as I supervise them* (S0031).

3.3 Differences in perceived nature of effective teaching and learning science among supervisors, mentors, and mentees

Also, the research question sought to examine whether differences existed among supervisors, mentors, and mentees on the three factors established as contributing to the perceived nature of effective teaching and learning science. To achieve this, multivariate analysis of variance (MANOVA) was used. To be sure of having selected the right statistics, first, normality and the presence of multivariate outliers were determined using the Mahalanobis distance [45]. Tabachnick and Fidell [46] explained Mahalanobis distance as the distance of a case from the centroid of the remaining cases where the centroid was the point created at the intersection of the means of all the variables. The purpose was to reveal any cases that lie at a distance from the other cases and such cases were considered outliers. In order to detect which cases were multivariate outliers, the critical X^2 value of the degree of freedom of the independent variables was compared with the Mahalanobis distance of the cases [46]. Any case whose Mahalanobis distance value was greater than the critical X^2 was considered an outlier.

According to Tabachnick and Fidell [46], research with the independent variable at three levels, such as teachers (supervisors, mentors, and mentees) should have a critical X^2 value of *16.27*. Thus, with the three independent variables in this research, the Mahalanobis were examined and five cases with extremely high critical values (case 49 with a critical value of 56.8; case 287 with 54.64; case 425 with 31.09; case 515 with 30.72, and case 498 with 29.24) were deleted [45, 46]. Another calculation of the Mahalanobis distance after deletion produced a few outliers whose critical values were much closer to the cutoff point. Hence, it was maintained to form part of the study. When Cook's distance (a measure of the influence of outliers on the model) was also examined, the maximum value was found to be *.056*. According to Ref. [46], if the Cook's distance was greater than *1*, then there was suspicion of the presence of outliers with a potential effect on the results. Since Cook's distance was less than *1*, then the researchers assumed there was no problem and that the data on effective teaching and learning science was suited for MANOVA statistics.

In furtherance, an inspection of the mean scores and results of the mean perceptions are presented in **Table 9**.

The results from **Table 9** indicated that mentors' perception of an effective science teachers' instructional processes was slightly higher (M = *22.52*, Std. = *3.46*) than supervisors (M = *21.88*, Std. = *3.78*) and mentees (M = *21.76*, Std. = *4.74*). Their lower standard deviation values also implied the scores were closely spread around their mean values. Again, the mean perception of effective teaching and learning science in terms of consciousness of professional demands in relation to supervisors (M = *30.78*, Std. = *5.72*), mentors (M = *30.51*, Std. = *5.12*), and mentees (M = *30.20*, Std. = *6.18*) were virtually the same. For a conducive learning environment, all three groups of teachers showed slight differences in their means with mentors showing a higher mean score (M = *105.54*, Std. = *14.68*) than mentees (M = *103.77*, Std. = *18.51*) and supervisors (M = *102.25*, Std. = *15.54*). Although differences in mean values existed in some cases, it was difficult to claim the difference was significant. Hence, there was the need to further examine the perceived nature of effective teaching and learning science by the groups of teachers using MANOVA.

In addition to assessing the fitness of the data on effective teaching and learning science for MANOVA statistics, homogeneity of variance was assessed and the results are presented in **Table 10**.

	N	Role as a teacher	M	Std.
Instructional processes	85	Supervisor	21.88	3.78
	160	Mentor	22.52	3.46
	271	Mentee	21.76	4.74
	516	Total	22.02	4.23
Consciousness of professional demands	85	Supervisor	30.78	5.72
	160	Mentor	30.51	5.12
	271	Mentee	30.20	6.18
	516	Total	30.39	5.79
Conducive learning environment	85	Supervisor	102.25	15.64
	160	Mentor	105.54	14.68
	271	Mentee	103.77	18.51
	516	Total	104.07	16.95

Table 9.
Mean scores on perceived nature of effective teaching and learning science.

Box's M	F	df1	df2	p
37.81	3.17	12	328844.497	.000*

**Significant at $p < .01$.*

Table 10.
Test of homogeneity of variance on effective teaching and learning science for MANOVA.

From **Table 10**, the results showed that the Box's M (*37.81*) was significant (p = *.000*). This implied there was a violation of the assumption on the homogeneity of variance. However, Tabachnick and Fidell [46] reported that with a large sample size, such as 516 in this research, the violation can occur because Box's M was too strict for larger sample sizes. Also, given that in this research the sample size was over 500, the violation was not a problem and hence, MANOVA was run. The researchers then went further to examine Levene's test of equality of variance. The results on equality of variance are presented in **Table 11**.

From **Table 11**, the results showed there was a violation of the assumption of the equality of variance at a significance value of *.01*. However, Pallant [45] indicated that where there was a violation of assumptions, Pillai's trace should be chosen over Wilker in presenting the findings and that a more conservative significance level of *.01* was needed.

Having checked these assumptions, a one-way between-groups MANOVA was performed to investigate how the three groups of teachers perceived the nature of effective teaching and learning science. The dependent variable, the perceived nature of effective teaching and learning science were of three levels; conducive learning environment, instructional processes, and consciousness of professional demands. The independent variable, the three groups of teachers (caption as the role of the teacher) was of three levels; supervisor, mentor, and mentee. The results of the multivariate test of significance are presented in **Table 12**.

	F	df1	df2	p
Instructional processes	6.961	2	513	.001*
Consciousness of professional demands	3.653	2	513	.027**
Conducive learning environment	6.895	2	513	.001*

***Not significant at p > .01.*

Table 11.
Test of equality of error variances on effective teaching and learning science using Levene's test.

Effect		Value	F	Hypothesis df	Error df	p	Partial Eta Squared
Role as a teacher	Pillai's Trace	.087	7.77	6.000	1024.000	.000*	.044

**Significant at p < .017.*

Table 12.
Multivariate test of significance on perceived nature of effective teaching and learning science.

The results from **Table 12** showed there was a statistically significant difference between the three groups of teachers (supervisors, mentors, and mentees) on the perceived nature of effective teaching and learning science. Because the calculated Pillai's Trace vale (*.087*) was significant ($F(3, 511) = 7.77$, $p = .000$). Hence, there was the need to examine further the differences in relation to supervisors, mentors, and mentees on the perceived nature of effective teaching and learning science. To do this, the researchers set a high alpha level to avoid committing a *type 1 error*. As the perceived nature of teaching and learning science was of three levels, the alpha level was set at *.017*. The results are presented in **Table 12**.

This MANOVA was conducted to examine the role of teacher (supervisor, mentor, and mentee) differences on the perceived nature of effective teaching and learning science. The continuous variables used in this aspect of the research were instructional processes, the consciousness of professional demands, and a conducive learning environment. The results are presented in **Table 13**.

Source	Perceived nature of effective teaching and learning science	Type III sum of squares	df	Mean square	F	p	Partial Eta Squared
Corrected model	Instructional processes	59.699[a]	2	29.850	1.670	.189*	.006
	Consciousness of professional demands	25.099[b]	2	12.550	.374	.688*	.001
	Conducive learning environment	654.766[c]	2	327.383	1.140	.321*	.004
Intercept	Instructional processes	201675.326	1	201675.326	11284.625	.000**	.957
	Consciousness of professional demands	385550.665	1	385550.665	11483.662	.000**	.957
	Conducive learning environment	4472229.780	1	4472229.780	15574.763	.000**	.968

Source	Perceived nature of effective teaching and learning science	Type III sum of squares	df	Mean square	F	p	Partial Eta Squared
Role as a teacher	Instructional processes	59.699	2	29.850	1.670	.189*	.006
	Consciousness of professional demands	25.099	2	12.550	.374	.688*	.001
	Conducive learning environment	654.766	2	327.383	1.140	.321*	.004
Error	Instructional processes	9168.177	513	17.872			
	Consciousness of professional demands	17223.381	513	33.574			
	Conducive learning environment	147305.860	513	287.146			
Total	Instructional processes	259324.000	516				
	Consciousness of professional demands	493726.000	516				
	Conducive learning environment	5736299.000	516				
Corrected Total	Instructional processes	9227.876	515				
	Consciousness of professional demands	17248.481	515				
	Conducive learning environment	147960.626	515				

**Not significant at p* > .017.

Table 13.
MANOVA statistics of three groups of teachers on perceived nature of effective teaching and learning science.

The results from **Table 13** showed that there was no statistically significant difference (using a Bonferroni adjusted alpha level of *.017*) in how the selected teachers perceived effective teaching and learning science in the basic schools. Because the mean perceived nature of effective teaching and learning science in relation to a conducive learning environment (M = *104.07*, Std. = *16.95*, F(*2, 513*) = *1.140*, p = *.321*) was not statistically different from the mean perception of instructional processes (M = *22.02*, Std. = *4.23*, F(*2, 513*) = *1.670*, p = *.189*) and the mean perception of consciousness of professional demands (M = *30.39*, Std. = *5.79*, F(*2, 513*) = *.374*, p = *.688*).

To triangulate this finding of no difference in the perceived nature of effective teaching and learning science among supervisors, mentors, and mentees, some selected teachers were interviewed using ESTIS. The results from the interview suggested all three groups of teachers perceived the nature of effective teaching and learning science in similar ways in terms of a conducive learning environment, instructional processes, and consciousness of professional demands. For instance, when all the teachers interviewed were quizzed "*How would you describe the effective science teacher's knowledge of content and instructional strategy?*" In terms of how he/she demonstrates the knowledge to create a conducive learning atmosphere. All supervisors, mentors, and mentees explained that effective teaching and learning science involved teachers giving a correct explanation of science concepts. That is, it reduced the ease with which students learn science in the classrooms. Excerpts are;

> *... explaining concepts well for learners to understand and attract their attention in class* (ME053).
> *An effective science teacher is someone who is confident and competent in explaining scientific concepts to students. You see this confidence will attract students to your lessons* (ME040).

> *... his/her ability to teach well the content with mastery and engagement of students for better understanding (*MR033).

> *through his/her lesson delivery on how systematic topics are explained for students' understanding. I must say I have seen students asking that mentees whose delivery is good should be retained in our school* (MR014).

> *The classroom environment strives for teachers' know-how. ... by explaining concepts taught well for learners to understand* (S005).

> *A good learning classroom is attained through his/her lesson delivery on how systematic topics are explained for students' understanding* (S011).

The teachers interviewed mentioned that at times some skills are needed in creating an enabling environment for students to learn science concepts. Those skills and knowledge can be acquired through professional development programs. Excerpts are:

> *personal reading and attending seminars, workshops, and symposiums on curriculum updates* (ME001).

> *Through reading science books and watching science documentaries. It can also be attained through researching more scientific concepts from the internet for further knowledge or attending seminars and workshops for the needed skills and knowledge teaching in the basic schools* (MR033).

> *personal reading and attending seminars, workshops, and symposiums on curriculum updates* (S002).

> *By upgrading through schooling or seminars. I must say knowledge of some skills is vital for the classrooms. They make students learn science at ease* (S005).

Also, the teachers interviewed mentioned that effective teaching and learning science should occur in a learning environment that sought to build students' confidence. Excerpts are:

> *... the classroom should be ideal for encouraging learners by placing them at the center of teaching and learning processes* (ME028).
> *Yes, because it builds students' confidence in the classroom and helps them satisfy their curiosity* (MR013).

> *building confidence by applauding students who perform well and encouraging those who do not do well*" (MR046).
> *by encouraging learners and then building their confidence in learning science ... the teacher places the students at the center of teaching and learning processes* (S010).

To create a conducive learning environment for students learning science in the basic schools, effective science teachers managed their classrooms. This was achieved through effective class control measures put in place by teachers. Excerpts are:

> *Yes, the creation of a learning classroom by giving clear and simple directions to obey rules and regulations in class which is seen through quietness … effective teachers use question skills to achieve this* (ME018).

> *students have been made to set classroom rules themselves knowing their respective consequences regarding rewards and punishments to help in class control* (ME024).

> *Yes, by giving clear and simple directions to obey rules and regulations in class, which is seen through quietness and giving questions to inattentive students in a class* (S012).

The teachers viewed mentioned that good class control would result in a conducive environment for a good teacher-student relationship leading to students feeling free to ask questions to aid their understanding of science concepts. An excerpt that was common to all teachers is:

> *Yes, when there is a conducive environment and good relationship between teacher and student, they are motivated to feel free and willing to ask questions during lessons* (ME024, MR013, and S024).

This and other common views probably explain why the mean perception values of the three groups of teachers are slightly different but not statistically significant.

With respect to the instructional processes, the teachers interviewed mentioned that effective teaching and learning science involved teachers selecting and using appropriate instructional strategies in the classroom to aid students' active participation in learning science concepts. Excerpts are:

> *Learning through active involvement in the lesson ensures quick absorption of science concepts by learners, hence, I expect an effective science teacher to organize his lesson to achieve that* (ME016).

> *An effective science is aware that the use of group activities helps involve everybody in the class including the weaker ones, so I present my lessons with that in mind* (MR055).

> *The use of group activities for teaching science is effective because two heads are better than one so students working in groups help them to share ideas* (S001).

The teachers interviewed mentioned that how teachers structured their instruction contributed to students' development of understanding of science concepts. Hence, instructional processes were key to effective teaching and learning science. Excerpts are:

> *The way the teacher plans and implements his or her teaching will make the lesson effective because students are able to construct knowledge among themselves and this aids their understanding* (ME051).

> *This is effective due to the different ideas possessed by group members, which are shared among themselves. It helps students to understand even difficult science concepts* (S002).

With respect to the consciousness of professional demands, the teachers interviewed held a much similar view. That is, for effective teaching and learning science to occur in basic schools, teachers should appreciate that they were to prepare a lesson plan and implement it in the classroom as planned. Excerpts are:

> *An effective science teacher prepares by planning and allocating a specific number of minutes to every stage and making sure times are used as planned* (ME028).
>
> *Effective teaching involves a teacher who prepares by having proper planning on when to use even the teaching materials* (MR001).
>
> *prepares by planning and allocating a number of minutes that will be used for every stage. The teacher has to follow the plan when teaching being conscious of the time scheduled for each stage of the lesson. I normally check and discussed with teacher trainees during supervision* (S008).

4. Discussion

The findings that effective teaching and learning science involves teachers who are mindful of instructional strategies to use in aiding students learning, perhaps one that lends itself to a constructivist approach confirms the findings of Adu-Gyamfi [14] that effective science teachers use appropriate teaching approaches and techniques and of Lumpkin and Multon [21] that effective teachers use various instructional strategies to convey course content to students to enhance their learning. It could be that the three groups of teachers are aware of Borich [20] indicators of instructional varieties and instructional strategies and that form the basis upon which all three groups of teachers evaluate effective science teachers. Because the characteristics of effective science teachers are evident and common [25] and can be recognized everywhere by science educators such as the three groups of teachers. Hence, it is not out of place that the three teacher groups (supervisors, mentors, and mentees) have a highly positive perception of teaching and learning science in basic schools. The Ghana Education Service through heads of the basic schools should occasionally engage the three teacher groups in professional development programs to share best practices and experiences on effective teaching and learning science. Again, the finding that effective teaching and learning science involves teachers who use instructional materials in their lesson delivery resonates with Lupascua et al.'s [26] assertion that in contemporary times effective science teachers use instructional materials. It, thus, implies that effective science teachers need to use instructional materials taking into consideration the concepts in context to explain the different learning styles of the learners and employ multimodal instructional materials as well as vary them. The perception of the three teacher groups of effective teaching and learning science is linked to teachers who prepare in advance and manages instructional time judiciously. This finding confirms earlier studies on effective [science] teachers as they manage their classes so that there is minimum wastage of class time and high levels of engagement [4, 36, 37]. Perhaps, it could be that they are able to do this because they prepare in advance [4, 27] and appreciate that contact hours are one of the important resources that teachers need not waste in order to cover the selected content by the curriculum developers. It is worth learning from this finding that when science teachers prepare in advance, they do things right [26]. Hence, school inspectors, during the monitoring

of schools, should look out for whether teachers consciously budget for the time they would spend in the classroom with students. Moreover, effective teaching and learning science involve teachers who have the ability to establish a good learning environment to facilitate the teaching and learning of science concepts. This finding is in line with earlier findings and descriptions of effective science teachers as those who plan for the environment, both the organization of the classroom and students [6, 19, 25, 29, 31]. Those organizations are geared toward creating a welcoming environment that fosters positive relationships among students regardless of disparities in ethnic background, gender, social class, handicap, or prior academic achievement [19]. It could be that effective science teachers are able to establish their enabling learning environment by monitoring students' behavior in the classroom [6]. In this enabling environment of science, teachers show great interest in their student's success and this cannot be ignored. It is, also, in line with Young and Shaw's [10] finding that effective teachers are rated very high because of their genuine respect for students, concern for student learning, and value of the course. Consequently, this enabling learning environment is one where teachers demonstrate adequate content knowledge and instructional strategy [2, 14]. Since knowledge is not constant, it stands to mean that effective science teachers strive to update their knowledge through research. It is also worth suggesting that opportunity needs to be provided to science teachers through in-service training, by managers of basic schools, to keep updating their knowledge and to broaden the horizon of their knowledge for effectively teaching science.

Three factors principally accounted for the teacher's perception of the nature of effective teaching and learning science are a conducive learning environment, instructional processes, and consciousness of professional demands. In a conducive learning environment, it is apparent that the teachers perceive that effective teaching and learning science involves teachers who show love and empathy to their students and create a good human relationship with their students. Such environments make students feel comfortable to ask questions to help build their knowledge and understanding [14, 37]. The supervisors, mentors, and mentees who have gone through science training themselves recognize that proper knowledge of the content of science and knowledge of how to transform this content form an integral part of science teaching and learning. Thus, teachers perceive that an effective teacher demonstrates this knowledge by giving detailed explanations of concepts, which is well justified with an appropriate instructional strategy. As educators, the teachers appreciate that effectiveness needs to be sustained as such they perceive effective teaching and learning science involves a teacher who conducts research to update his/her knowledge and conceptual understanding of science concepts, ideas, and principles that needed explaining to students. There is, therefore, a need for Ghana Education Service to organize professional development programs for experts to share experiences on contemporary approaches to creating a conducive learning environment for basic school students. On the part of instructional processes, it came to bear that effective teaching and learning science involves teachers who by nature care about students' prior knowledge, simplifying the provided learning material in ways that meet individualized needs and respecting the diversity of any kind, ensuring solidarity and implementing democratic procedures, reducing students' learning load, and encouraging feedback [39]. The teachers' perception that as part of the instructional processes of effective teachers, they make their lessons participatory could be because they might have been aware that participatory approaches, a constructivist approach, enable students to make meaning of science concepts by themselves. Moreover, the teachers' perception of effective teaching and learning science in relation to teacher

consciousness of professional demands helps basic school teachers to manage their time well. This confirms earlier findings [14, 37] that effective teachers manage their time to avoid wastage of instructional time. The teachers perceive that effective science teachers by their nature take time to explain to students difficult concepts. As much as possible, science educators in colleges of education should maximize the use of instructional time as they prepare preservice teachers. This will make their students see them as role models and, hence, adopt best practices as they handle science in the basic schools.

The findings that there was no statistically significant difference in the mean perceptions of the three groups of teachers on conducive learning environment, instructional processes, and consciousness of professional demands in relation to effective teaching and learning science implies that the science teacher educators (supervisors) might be doing a good job. Because of this, no statistically significant difference among supervisors, mentors, and mentees has once been reported [42] on teachers' perspectives on the effective use of teaching and learning resources in science lessons. Hence, science educators and researchers should conduct further research to investigate curriculum structure and how college tutors conduct their classroom activities to share with the world what the initial teacher training is and its impact on preservice teachers. It could also be that the supervisors have instilled in their students (mentors & mentees) lifelong learning of effective teaching and learning science. In addition, it could be a confirmation of earlier studies that educators have an influence on preservice (mentees) and in-service (mentors) teachers' conception of effective teaching, and this also influences their practices [3, 40, 41]. It is that the supervisors prepare the preservice teachers to develop appropriate knowledge, strategies, and techniques relevant to creating an enabling environment for learning science who eventually continue this acquired (mentors). However, the supervisors need to be aware preconceptions held on by preservice education may be retained by preservice teachers despite methodology units and practicum experiences [41] and help them to address them appropriately.

5. Conclusion and implications

This chapter studied the perceived nature of effective teaching and learning science among supervisors (who were college tutors), mentors (who were in-service teachers in basic schools), and mentees (who were preservice teachers in colleges of education). These teacher groups were linked in common as they were mandated to effective teaching and learning science in the basic schools. Having responded to a questionnaire and interview, through the triangulation mixed methods, the three groups of teachers had highly positive perceptions of effective teaching and learning science in basic schools. Hence, science educators and researchers should case-study effective teaching and learning science in basic schools through observer participation or participation observer to further investigate whether teachers practice what they professed to teach. The factors underpinning this highly positive perception of effective teaching and learning science were a conducive learning environment, instructional processes, and consciousness of professional demands. However, supervisors, mentors, and mentees shared a common perception and did not differ statistically on conducive learning environments, instructional processes, and consciousness of professional demands in relation to effective teaching and learning science though qualitatively some issues were expressed differently by the three groups of teachers.

Hence, the Ministry of Education through the Ghana Education Service should provide opportunities for the three groups of teachers to meet and share experiences on effective teaching and learning science in basic schools.

Appendix A

A.1 Effective science teacher questionnaire

Dear teacher,

This questionnaire seeks your opinions and concerns about the perceived nature of an effective science teacher**.** You are required **NOT** to write your **name** and the name of your **college or school**. Your response(s) to this questionnaire will remain **confidential** and any comment made will not be personalized in this research. The information provided will be used to improve the teaching and learning of science in schools and colleges. Completing the questionnaire means you are consenting to take part in the research.

Please carefully read all the instructions in each section before giving your response(s).

SECTION A: Background Information.

1. Zone

… .

2. Sex

Male [] Female [].

3. Level of Teaching

College Tutor [] Primary School Teacher [] JHS Teacher []

4. Role as a Teacher

Supervisor [] Mentor [] Mentee []

SECTION B: Perceived Nature of Effective Teaching and Learning Science.

Indicate your level of agreement (**from 1 to 5**) to the following statements on how you consider as an effective science teacher. A rank of 1 is the lowest agreement and a rank of 5 is the highest agreement.

Tick [√] to show your level of agreement.

Lowest to Highest Agreement

Item	Statement	1	2	3	4	5
5.	An effective science teacher selects and uses instructional strategies					
6.	An effective science teacher studies the curriculum to guide their choice of appropriate teaching method					
7.	An effective science teacher often reviews students' relevant previous knowledge and builds on them					
8.	An effective science teacher uses activity-based methods of teaching					
9.	An effective science teacher uses the lecture method of teaching					
10.	An effective science teacher uses methods that make his/her lessons practical, and collaborative/participatory					

Item	Statement	1	2	3	4	5
11.	An effective science teacher teaches science through practical works that are laboratory-based to enhance student understanding					
12.	An effective science teacher relies on textbooks to teach science					
13.	An effective science teacher teaches scientific concepts and ideas using a methodology that aids the application of the knowledge to everyday life experiences					
14.	An effective science teacher is a teacher who uses real-life illustrations to explain various scientific concepts					
15.	An effective science teacher varies instructional strategies and techniques when necessary to suit the learning needs of students					
16.	An effective teacher uses more than one teaching and learning material					
17.	Effective science teacher ensures that their teaching resources are available before they start their lessons					
18.	An effective science teacher is good at improvisation of teaching and learning materials					
19.	An effective science teacher uses multiple teaching and learning materials for the explanation of the same concept					
20.	An effective science teacher selects and uses teaching and learning materials in teaching to enhance students' conceptual understanding of scientific concepts and ideas					
21.	An effective science teacher employs teaching and learning materials that arouse the desire of learners to learn					
22.	An effective science teacher prepares in advance before coming to class					
23.	An effective teacher is confident because he prepares well in advance to produce higher student achievements					
24.	An effective science teacher is someone who tries as much as possible to find something in the community, within his busy schedule, to relate every topic for easy student understanding					
25.	An effective science teacher is hardworking whose effort enables his/her students to excel in examinations and assessments					
26.	An effective science teacher is creative in teaching science					
27.	An effective science teacher is one who never misses his/her instructional hours					
28.	An effective science teacher plans and teaches within the given instructional time					
29.	An effective science teacher takes his/her time to teach without rushing through the presentation of lesson					
30.	During practical lessons, an effective science teacher finds enough time to demonstrate concepts to students					
31.	An effective science teacher is a teacher who will have time to explain to students aspects of topics that are difficult to understand					
32.	An effective science teacher uses instructional time consciously to the benefit of students					
33.	An effective science teacher creates a conducive environment for students learning of scientific concepts and ideas					
34.	Effective science teachers' lessons are always interesting and enjoyable.					
35.	An effective science teacher always responds appropriately to questions students ask					

Item	Statement	1	2	3	4	5
36.	An effective science teacher uses formative assessment to sustain students' interest in learning					
37.	An effective science teacher has good human relationships between science teachers and students during science lessons					
38.	An effective science teacher loves and shows empathy for students					
39.	An effective science teacher is an open-minded person creating room for constructive criticism					
40.	An effective science teacher motivates students to learn science					
41.	An effective science teacher creates a learning environment that allows students to ask questions about the materials being studied					
42.	An effective science teacher guides students on how to search for answers to questions raised					
43.	An effective science teacher builds his/her students' confidence in learning of the subject science					
44.	An effective science teacher provides students with the experiences needed to learn science					
45.	An effective science teacher has good class control					
46.	An effective science teacher presents his/her lessons systematically and orderly					
47.	An effective teacher arranges topics sequentially in a systematic order to allow him/her to teach from simple to complex					
48.	An effective science teacher ensures that everyone understands the first topic before moving to the next topic					
49.	An effective science teacher gives a kind of exercise that will demand a lot of research for about week					
50.	An effective science teacher evaluates learners in science class					
51.	An effective science teacher monitors learners in science class					
52.	An effective science teacher gives students enough work examples for them to practice					
53.	An effective science teacher always gives an assignment to his/her students, marks, and discusses it for the students to know their shortcomings for rectification					
54.	An effective science teacher distributes questions to all students in science lesson					
55.	An effective science teacher uses simple vocabulary that can be understood by all students in science lesson					
56.	An effective science teacher communicates science terminologies very well to the understanding of students					
57.	An effective science teacher can be tolerant of all students' questions and issues in science lessons					
58.	An effective science teacher responds swiftly to students' questions raised during lesson					
59.	An effective science teacher provides students with opportunities to develop the knowledge, skills, and attitudes they need in the classroom.					
60.	An effective science teacher considers individual intellectual abilities in teaching scientific concepts and ideas to a class of students					

Item	Statement	1	2	3	4	5
61.	An effective science teacher considers the academic level of students in teaching scientific concepts and ideas					
62.	An effective science teacher considers the level and stages of the students in order to know the techniques, strategies, and methods to use in teaching					
63.	An effective science teacher always provides students with an opportunity to work toward improving their shortfalls in learning science					
64.	An effective science teacher prepares students to perform creditable well in examinations.					
65.	An effective science teacher demonstrates sufficient knowledge of science to students					
66.	An effective science teacher should have in-depth knowledge of the topic before teaching					
67.	An effective science teacher is a teacher who justifies what he/she is teaching to the admiration of students					
68.	An effective science teacher is abreast of the current state of scientific knowledge					
69.	An effective science teacher conducts research to update his/her knowledge and conceptual understanding of scientific concepts, ideas, and principles					
70.	An effective science teacher demonstrates his/her knowledge of the content by giving detailed explanations of scientific concepts, ideas, and principles when teaching					
71.	An effective science teacher can justify what he/she is teaching using the appropriate approach					
72.	An effective science teacher uses appropriate instructional strategies to present the content					
73.	An effective science teacher uses a variety of approaches to avoid boredom during science lessons					

Appendix B

B.1 Effective science teacher interview schedule

This interview schedule is designed to interact with science teachers on a one-to-one interview to seek their views on who an effective science teacher is. Your response (s) to this interview will remain **confidential** and any comment made will not be personalized in this research. The information provided will be used to improve the teaching and learning of science in schools and colleges. Transcribed audiotapes will be sent to teachers for their approval and any materials that will form part of the final study will have their consent.

A. Bio-Data for teachers

1. How long have you been teaching in this school?
   ... ...

2. How long have you been teaching science?
   ... ...

3. What is your academic/Professional qualification?
… …

B. Who is an effective science teacher?

4. What instructional strategies do effective science teachers normally use in teaching science?

Prompt 1: why those strategies?
… …
… …
… …

Prompt 2: is it by group activities? Why?
… …
… …
… …

Prompt 3: is it by hands-on activities? Why?
… …
… …
… …

Prompt 4: is it by demonstration? Why?
… …
… …
… …

Prompt 5: is it by lecture? Why?
… …
… …
… …

5. How does an effective science teacher acquire and use Instructional materials?
… …
… …
… …

Prompt 1: what type of instructional materials do they use? Why?
… …
… …
… …

Prompt 2: how do they get them?
… …
… …
… …

Prompt 3: do they use more than one instructional material for lesson delivery? Why?
… …
… …
… …

6. How does an effective science teacher prepare in advance as well as manage his/her time for science lessons?

Prompt 1: does he/she prepare lessons before coming to class? Why?
… …
… …
… …

Prompt 2: does he/she allocates time for each stage of lesson delivery? Why?

... ...
... ...
... ...

Prompt 3: how does he/she organizes his/her instructional materials? Why?

... ...
... ...
... ...

7. How do you see the learning environment of an effective science teacher's class?

Prompt 1: does he/she build the student's confidence? how?

... ...
... ...
... ...

Prompt 2: does he/her have good class control? What are the indicators?

... ...
... ...
... ...

Prompt 3: are students free and willing to ask questions? Why?

... ...
... ...
... ...

Prompt 4 does he/she provides students with opportunities to develop the knowledge, skills, and attitudes they need in the classroom? How?

... ...
... ...
... ...

8. How would you describe the effective science teacher's interest in students' academic improvement?

Prompt 1: does he/she considers the students in the preparation of lessons? Why

... ...
... ...
... ...

prompt 2: is his/her lesson structured to prepare to work toward their success? Why?

... ...
... ...
... ...

Prompt 3: does he/she consider the intellectual abilities of the learners? Why

... ...
... ...
... ...

9. How would you describe the effective science teacher's knowledge of content and instructional strategy?

Prompt 1: how is his/her knowledge being demonstrated?

... ...
... ...
... ...

Prompt 2: how does he/she updates his/her knowledge? why?

... ...

… …
… …

Prompt 3: how does he/she explain scientific concepts, ideas, and principles when teaching? Why?

… …
… …
… …

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