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St. Lucian Elementary School Teachers' Applicability Beliefs and Beliefs about Science Teaching and Learning: Relevance to Their Level of Inquiry-Based Instructional Practices in Science

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Abstract

This paper examines the hypothesis that St. Lucian primary school teachers' science teaching and learning beliefs and their applicability beliefs are stronger predictors of their science teaching strategies than their teacher education experiences. Quantitative procedures were used where the level of each belief construct as well as their underlying constructs was measured in each teacher in the population and a determination made as to their favourability towards inquiry-based instruction (IBI). The levels of a sample of these teachers' IBI practices were also determined using an observational rating scale. Multiple regression analyses were used to determine the extent to which teachers' beliefs serve as predictors of their IBI practices. The results showed that teachers' applicability beliefs were barely moderately favourable to their practice of IBI, while their beliefs about science teaching and learning were favourable. Their inquiry-based practices were found to be at the unsatisfactory developing inquiry level. While their science teaching and learning beliefs were found to be significant and moderately positive predictors of their inquiry-based instructional practices, their applicability beliefs seemingly functioned as a moderating variable that limited the effect of teachers' favourable science teaching and learning beliefs on their instructional practices. These findings are significant in that they show the detrimental effect school-based factors can have on teachers' instructional practices in science.

Keywords: inquiry-based instruction, applicability beliefs, science teaching and learning beliefs

1. Introducation

St. Lucia is an island in the Caribbean and one of the nine members of the group of nations referred to as the Organization of Eastern Caribbean States (OECS). As a member of that organization, St. Lucia is signatory to a number of treaties aimed at fostering greater cooperation among member states. Part of this collaboration involved a collaborative reform of the education system which is managed by the OECS Education Reform Unit (OERU). Part of that reform involved the production of the OECS Harmonized Primary School Science and Technology Curriculum.

The implementation of this curriculum began in 2007 throughout the OECS. In addition to the new focus of integrating science with technology, the aims and goals of the curriculum gave clear indications that the required approach to instruction was one based on inquiry methods.

The initial teacher education curriculum in St. Lucia and the rest of the OECS is managed by the School of Education of the University of the West Indies (UWI). Inquiry-based approaches are emphasized in both the science and mathematics education curricula of the Certificate and Associate Degree programmes in primary education. According to the 2011-2012 Education and Culture Statistical Digest from the Ministry of Education (M.O.E, 2011), as of the 2011/2012 academic year 90% of primary school teachers in St. Lucia are trained and are therefore assumed to have both the theoretical and practical knowledge of inquiry-based instruction.

Despite these facts, there is a strong perception among science educators and curriculum officers that a majority of teachers in both primary and secondary schools in St. Lucia mainly use the traditional didactic approaches in their implementation of science curricula. From the lead researcher's experience as a secondary school science teacher, primary school principal, and teacher education lecturer, these reports appear valid. Therefore, there seems to be an apparent disconnect between the strategies learnt and practiced by teachers at their institution of teacher education with those used by these same teachers at their schools of employment.

Casual conversations between the researchers and both primary and secondary school teachers in St. Lucia indicate that many of them may be encountering problems implementing the science and technology curriculum using inquiry-based approaches. Although this problem may stem from a variety of sources, the researchers are of the view that a common thread is the beliefs that these teachers hold about the subject, their knowledge of various instructional approaches and strategies, and the applicability of these approaches and strategies to the learning conditions of their schools and classrooms.

1.1 Approaches to Science Instruction

An important factor determining the quality of the teaching-learning process in the science classroom is the approach taken by the science teacher to teach science. In the context of the classroom, an approach to instruction can be considered to be the way in which a teacher conceptualizes instruction and how it should be conducted to best facilitate student learning. So the approach to instruction will have a direct impact on the instructional strategies used by a teacher.

Since a teachers' approach to science instruction is a conceptualization of that teachers' understanding of the nature of science instruction that would best facilitate students' learning, then that approach can best be determined by observing the actual teaching strategies used by the teacher during science instruction. Also, in order to best make that determination, there must be some 'conceptual yardstick' that would allow some kind of measurement to be made as to where a particular approach will fall along a continuum of 'teaching practice'. One such continuum has been clearly identified in the literature as ranging from a teacher-centered traditional approach to a student-centered inquiry-based approach, with the latter being identified as the preferred approach for effective science instruction.

1.1.1 Traditional Teacher Centered Approaches to Science Instruction

As far back as 1909, John Dewey addressed the education section of the American Association for the Advancement of Science (AAAS) and proclaimed his view that

> "Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much subject matter of fact and law." (Dewey, 1910, p.124; cited in Bybee, Powell and Trowbridge, 2008).

This view is probably as relevant now as it was then and highlights an important characteristic of the traditional teacher-centered approach to science instruction; that the teacher is the primary source of knowledge in the classroom, and his or her primary role is to present that content to the students usually using lecture oriented teaching strategies.

This approach is referred to as traditional since, even though criticized by Dewey and others from as far back as the early 20th century, it has arguably remained the primary approach to science instruction at all levels of the education system up to the present day. It is also referred to as teacher-centered because of the implicit roles of the teacher and students in the teaching-learning process. Since the teacher is the primary source of knowledge, the students are seated at desks usually in rows and columns with their attention focused on the teacher. The teacher may be seen presenting information to the students in one of a variety of methods.

In this approach the students are generally passive learners rather than being actively involved in the learning process. It has to be re-emphasized that the approach is really the teacher's conceptualization of the teaching-learning process and it is reflected in the particular teaching strategies used. So a particular approach may not dichotomously be either teacher-centered or student centered. Very often, there may even be both teacher-centered and student-centered instructional strategies being used in the same lesson. However, a preferred approach can normally be detected in the repeated observations of a teacher's lessons. So, instead of a dichotomous interpretation, a teacher's approach to teaching science may actually lie somewhere along a continuum of being totally teacher-centered to totally student-centered. Both of these extremes may not represent the ideal situation for science instruction. In order to understand where the ideal balance should be, it is necessary to consider what is meant by a student-centered approach. In science instruction, an inquiry-based approach is a student-centered approach recommended by reputable international organizations, educators and researchers as the preferred approach to teach science.

1.1.2 Inquiry-Based Approaches to Science Instruction

A focus on inquiry-based instruction (IBI) can be traced back to the early 20th century when Dewey, in his criticism of the then teacher-centered approaches to science instruction, argued for teaching science as inquiry where there is emphasis on the development of thinking and reasoning skills as well as an understanding of the processes of science. From that era, learning has increasingly been portrayed as being an active process where students are actively engaged in their learning of science rather than the traditional passive receiving of information from teachers. Good science teaching came to be increasingly associated with IBI (Anderson, 2002).

The National Science Education Standards (NSES) were published in 1998 to:

> "emphasize a new way of teaching and learning about science that reflects how science itself is done, emphasizes inquiry as a way of achieving knowledge and understanding about the natural world…"(NRC, 1996, p.9).

These standards, together with the publication 'Benchmarks for Science Literacy' produced by project 2061 of AAAS, offered a comprehensive guide for inquiry-based science instruction (Bybee, Powell and Trowbridge, 2008).

The guidelines outlined by the NRC in the NSES actually give a comprehensive description of how science education should be conducted from Grades k-12 (Kindergarten to the end of high school). In the guidelines is the suggestion that all students, even those in the earliest grades, should be made to experience science:

> "…in a form that engages them in the active construction of ideas and explanations and enhances their opportunities to develop the abilities of doing science" (NRC, 1996, p.121).

So, according to Von Seeker (2002), these standards encourage teachers to replace traditional teacher-centered teaching practices with inquiry oriented approaches.

The essence of IBI is based on Dewey's assertion that learning actually begins when the learner is placed into some sort of perplexity, confusion or doubt (Dewey, 1910). Cognitive psychologists later referred to this as a state of disequilibrium. To overcome this state, the learner searches for solutions by engaging in inquiry and reflective thinking (Duffy and Raymer, 2010). So all the instructional strategies which are encompassed by inquiry-based approaches center on the active involvement of students in their own learning which is stimulated by exposing them to situations which effectively place them into this state of disequilibrium.

1.2 Teachers' Educational Beliefs and their Classroom Behaviours

Since the 1980s, there have been several studies investigating the role of individual's beliefs in their actions and decision making. Pajares (1992) did a synthesis of such studies and indicated that they were generally based on the assumption that beliefs are the best indicators of the decisions individuals make throughout their lives (e.g. Bandura, 1986; Dewey, 1933; Nisbett and Ross, 1980; Rokeach, 1968). Pajares therefore concluded that research into teachers' beliefs is important since it may inform educational practice in ways that had previously not been accomplished by the educational research of the time.

Pajares (1992) also noted Dewey's interpretation of the crucial importance of beliefs in that it:

> "…covers all matters of which we have no sure knowledge and yet, which we are sufficiently confident of to act upon" (Dewey, 1933, p.6).

Sigel (1985) provided a definition which took into consideration the importance of individual's experiences in the development of beliefs. According to Pajares (1992), he defined beliefs as "Mental constructions of experience, often condensed and integrated into schemata or concepts… are held to be true and that guide behavior" (Sigel, 1985, p. 351). This definition also highlights the view that beliefs do not necessarily require a condition of truth. Irez (2007) synthesized the definitions of a number of researchers (e.g. Clark and Peterson, 1986; Nespor, 1987; Pajares, 1992; Richardson, 1996) and provided the general definition that:

> "Beliefs are psychological constructs that (a) includes understandings, assumptions, images or propositions considered to be true, (b) drive a person's actions and support decisions and judgments, (c) have highly variable and uncertain linkages to personal, episodic and emotional experiences, (d) although undeniably related to knowledge, differs from knowledge in that beliefs do not require a condition of truth" (Irez, p. 17).

The assumption can therefore be made that teachers' instructional decisions in their science lessons may be a function of a number of factors, one of which is the educational beliefs that they hold.

The nature of the beliefs related to the teaching-learning process that can be developed by teachers can be wide and varied. In order to truly understand the relationships between teachers' beliefs and their practices, it is probably necessary to examine the particular types of belief constructs separately rather than the general belief construct.

Levitt (2001) identified teachers' beliefs about teaching and learning as important in that they underlie the processing of a multitude of information that a teacher is presented with in the classroom. He added that these beliefs filter the information received by the teacher, resulting in particular classroom behaviours. Based on this review of literature, the researchers also conceptualized the situation-specific term applicability beliefs, which reflect teachers' beliefs about the implementation of IBI in their particular physical, psychological and social classroom contexts.

Beliefs about science teaching and learning, refer to beliefs about science and its nature (Irez, 2007), and beliefs about the teaching and learning of science (Jones and Carter, 2007). These beliefs develop from teachers' experiences as students, teachers, and in their years of teacher education. They may also be influenced by in-service professional development activities. Teachers' beliefs about science teaching and learning would most likely have a direct impact on their instructional practices in science.

Of particular importance to teachers' beliefs about science teaching and learning, are the approaches and strategies to the teaching of science that they were exposed to as student teachers, and also recommended by curriculum documents as what should be used in their teaching of science. These inquiry-based approaches are in many cases contrary to what these teachers were exposed to as students in primary and secondary institutions. In addition, researchers have pointed to a multitude of school and classroom variables that may have a strong impact on classroom teaching and learning and are not taken into consideration in teacher education programmes or the planning of subject curricula. In-service teachers may therefore develop what the researchers view as a variety of applicability beliefs referring to the applicability of the recommended inquiry-based approaches to the learning conditions of their schools and classrooms.

1.2.1 Teachers' Beliefs about Science Teaching and Learning

Teachers' beliefs about science teaching and learning, which are constructed from teachers' experiences as students in elementary and secondary schools, may actually be quite different from those espoused by teacher education curricula since, as previously indicated, the literature suggests a predominance of traditional teacher-centered approaches in schools, as opposed to the student centered IBI required by teacher education curricula. Therefore, if beliefs are stable and resistant to change, as indicated by Pajares (1992), then primary teachers' beliefs about science teaching and learning may be more the result of their years of schooling than their teacher education programmes or their experience teaching science.

Munby (1984) approached the issue of beliefs about science teaching and learning in a different way. He asserted that the treatment given by teachers to novel approaches is linked to their perception, which itself is a function of beliefs about what is important to teach, how teaching should be conducted and how learning occurs. It is a reasonable argument that the IBI experienced during teacher education is novel to teachers since their previous exposure was to traditional approaches. Hence, as alluded to by Munby (1986), they may not adequately relate to these IBI strategies and, as indicated by Jones and Carter (2007), this may affect the type of instructional behaviours they actually exhibit in the classroom. These beliefs may also influence teacher-student relations (Saker, 2010), and the planning of teaching (Song, Hannifin & Hill, 2007).

1.2.2 Teachers' Applicability Beliefs

Duffy (1982) posited the view that teachers' theoretical beliefs are situational and is reflected in their instructional practices only in relation to the complexities of their schools and classrooms. Many researchers have pointed to a variety of school and classroom-based barriers to effective IBI. In many cases, the findings of these researchers were based on the views of experienced teachers relating their experiences using IBI. These barriers to IBI may be wide and varied and may be a result of the particular socio-cultural and environmental conditions at a school. They may also have to do with individual teachers' perceptions of their role as science teachers and their social relationships with students, other teachers and the school administration. In effect, these teachers may develop a distinct set of beliefs about IBI as a result of these school-based factors that may inhibit, or even encourage their IBI practices. These beliefs are referred to in this study as applicability beliefs.

A number of researchers have indicated inconsistencies between teachers' theoretical beliefs and their classroom practices (e.g. Cain, 2009; Fang, 1996; Duffy, 1982). These theoretical beliefs would most likely have been developed during the years of teacher education since the inconsistencies generally has to do with teachers' lack of use of the teaching approaches and strategies learnt and practiced during teacher education. It is quite possible that these inconsistencies are due to the development of applicability beliefs as teachers enter the schools and gain experience teaching the science curriculum. Hence, the consistency of teachers' practices may be more with their applicability beliefs than with the epistemological beliefs developed earlier.

1.3 Research Problem

This study seeks to investigate primary school teachers' beliefs about science teaching and learning, and applicability beliefs related to inquiry-based science instruction, and whether these beliefs could reasonably be said to serve as predictors of their use of IBI strategies in the implementation of the science and technology curriculum in St. Lucia.

1.4 Research Hypothesis

The applicability beliefs, and beliefs about the teaching and learning of science possessed by trained primary school teachers in St. Lucia are significant predictors of their level of use of inquiry-based instructional approaches in their implementing of the science and technology curriculum in St. Lucia.

1.5 Research Questions

1) What is the level of primary school teachers' (a) beliefs about the teaching and learning of science and (b) applicability beliefs related to their use of IBI practices in the implementation of the science and technology curriculum?
2) What is the level of use of IBI strategies in primary school teachers' science instruction?
3) How do the levels of primary school teachers'

a) beliefs about the teaching and learning of science
b) applicability beliefs

independently predict their level of use of IBI strategies?

2. Method

A quantitative approach was used in the collection and analysis of data that allowed:

a) Survey techniques to be used to measure teachers' beliefs on each belief construct.
b) An observational rating scale to be used to measure teachers' level of inquiry-based instructional practices.
c) Multiple regression analyses to be used to determine the extent to which the beliefs of primary school teachers predict their use of inquiry-based instructional activities.

2.1 Population and Sample

2.1.1 Population

St. Lucia has eight educational districts identified as district 1 to district 8. Trained teachers from the junior primary grades (i.e. grades 3 to 6) from districts 1 to 8 were selected as the population for the study. Trained teachers were selected because of their assumed knowledge of inquiry-based techniques in science instruction. Data from the 2011 Education and Culture Statistics Digest of St. Lucia (Data Management, Corporate Planning Unit, M.O.E., 2011) indicated that there are 424 trained teachers in these districts teaching grades 3 -6 which therefore represents the total population for the study. Table 1 below shows the distribution of the population by district and gender.

Table 1. Population by educational district and gender

District	Population	Male	Female
1	62	6	56
2	58	4	54
3	54	9	45
4	51	5	46
5	61	9	52
6	65	9	56
7	43	6	37
8	30	4	26
Total	424	52	372

2.1.2 Selection of Samples

A sample of schools from each district was selected for the initial pilot testing of the survey instrument. The schools were selected by a combination of random and purposive sampling. The schools that were purposively selected were chosen because these schools had a very small population of teachers and students and very small class sizes.

The sample for the survey to determine and measure the beliefs of trained primary school teachers was obtained by subtracting the sample for the pilot testing from the total population. It was deemed necessary to use the whole sample because of its relatively small size and to enable a greater level of accuracy and robustness in the analysis of the data and interpretation of the results. The sample for the survey was therefore 341.

Stratified random sampling techniques were used to select 25 % of the population (approximately 87 teachers) for the lesson observation phase of the study. Stratification was used to ensure that:

- Teachers from each district were chosen in proportion to the total number of teachers from the population in the district.
- Teacher(s) from each primary school were chosen in proportion to the number of teachers in that school.
- The gender proportion in the sample was the same as in the population for each school and district.
- As far as was reasonably possible, the sample for each district contained equal numbers of teachers per grade level.

In order to select the 25 % of the population with the appropriate gender proportion, the relevant calculations were made and table 2 constructed showing the sample size by district and gender.

Table 2. Allocation of sample for lesson observation by district and gender

District	Sample size	Male	Female
1	14	2	12
2	11	2	9
3	10	2	8
4	10	2	8
5	13	4	9
6	14	3	11
7	9	1	8
8	6	1	5
Total	87	17	70

The sample was selected using the following procedure.

1) The name of each of the 341 teachers in the survey sample, their gender, school, and grade level were written on index cards and arranged into 8 groups according to district.
2) For each district, the cards were further categorized according to schools.
3) For each school, the appropriate number of teachers was selected

The 87 teachers in the sample allowed the recommended number of participants in each group selected for the multiple regression analyses. According to Soper (2011), for two predictor variables, an anticipated effect size of 0.15, and a statistical power of 0.8, the minimum sample size required for a multiple regression is 67. Hence the sample size selected was more than adequate for the intended analytical procedures.

2.2 Data Collection Instruments

2.2.1 The Questionnaire

The questionnaire was constructed to obtain data from the population required for measurement of their (a) beliefs about the teaching and learning of science, and (b) applicability beliefs. It consisted of three sections.

The first section was designed to obtain demographic information from the population. So this section provided information on the independent variables:

The second section was a Likert scale designed to measure teachers' beliefs about the teaching and learning of science. Questions were either constructed by the researchers based on the analysis of the literature review, or adapted from the CBAITLEI instrument constructed by Ibrahim (2003). Questions were added to better reflect the focus of this study especially as it related to the research questions and the population.

The third section was designed to measure teachers' applicability beliefs related to science and scientific inquiry. All questions were constructed by the researchers based on the analysis of the literature.

2.2.2 Lesson Observation Rating Scale

The instrument for the lesson observations was designed to answer research questions 2 and 3. It was adapted from a model of inquiry-based instructional assessment designed by Marshall, Smart and Horton (2010). The instrument is referred to as the Electronic Quality of Inquiry Protocol (EQUIP) and was constructed and designed to allow a comprehensive and quantitative measurement of various aspects of inquiry-based instructional activities used by teachers during instruction.

The instrument is composed of eight sections (I to VIII). The first three sections were used for descriptive information about the class and detailed notes about the instructional activities occurring.

Section IV – VII are the grading sections where the assessor assigns a mark from 1-4 based on the level of inquiry observed for various components of the lesson. The factors related to IBI assessed by each section are as follows:

Section IV assessed instructional Factors.

Section V assessed teachers' discourse factors.

Section VI assessed assessment factors.

Section VII assessed various curriculum related factors.

For each construct, the assessor determines the level of inquiry observed based on the following rating scale

1) Pre-inquiry
2) Developing inquiry
3) Proficient inquiry
4) Exemplary inquiry

Section VIII is for the summative overview of the lesson. The assessors gave a comprehensive score for each of the four factors: Instruction, Discourse, Assessment, and Curriculum. This comprehensive score was not necessarily the total score for the factor but an integer from 1 to 5 that corresponds with an appropriate level of inquiry observed. The overall view of the lesson was a score ranging from 5 to 20.

In order to obtain a good representation of the level of inquiry-based instructional practices of each participant in the lesson observation, the assessor observed consecutive lessons forming a unit of work. This is because the teaching strategy would normally vary depending on the actual content being covered and the stage of the unit that a lesson is being observed. It was the researchers' view that if consecutive lessons in a particular unit are observed, then there could be a more accurate assessment of the teachers' instructional practices since a range of possible strategies would more likely be observed. The number of lessons observed for each participant ranged from a minimum of 3 to a maximum of 5. A double lesson was counted as two lessons.

2.3 Establishment of Validity and Reliability of the Instruments

2.3.1 Face and Content Validity of the Questionnaire

For the questionnaire, face and content validity were assessed by three professional science educators. A few alterations to a number of items were suggested by assessors in addition to some minor changes in the format of the questionnaire. These were all promptly made prior to the pilot testing of the questionnaire.

2.3.2 Construct Validity of the Questionnaire

During the pilot testing, the teachers were instructed to indicate problems with the questionnaire as a whole or with individual items. No significant areas of concern were pointed out by the teachers.

After the pilot testing, Principal Component Analysis (PCA) with orthogonal varimax rotations were performed on sections B and C of the instrument. The data was therefore coded and entered into SPSS 18. PCA was conducted to identify the major underlying dimensions of the beliefs about science teaching and learning inventory and the applicability belief inventory, and also to possibly streamline these inventories to more effectively assess the belief constructs. The number of components retained was determined by following criteria identified by Field (2005).

Since section B of the questionnaire was in two parts, the first focusing on teacher activities and the second, student activities, factor analyses were done for each section separately. The results are shown in table 3 and 4 below.

The interpretations of the components, which therefore formed the underlying constructs of teachers' beliefs about science teaching and learning, are shown in table 5.

Table 3. Interpretation of components extracted from factor analyses of section C of the questionnaire

Component	Interpretation
1	Teachers' beliefs of the mode of instruction that would best facilitate students' learning of science content.
2	Teachers' beliefs about how they should present the content to students.
3	Teachers' beliefs about their role in the provision of instructional factors
4.	Teachers' beliefs about the manner of student engagement in instructional activities.
5	Teachers' beliefs about how students should best learn the science content.

The results of the factor analyses for section D of the questionnaire and the interpretation of the components, which, therefore, formed the underlying constructs of the applicability belief scale, are shown in table 4

Table 4. Interpretation of components extracted from factor analyses of section D of the questionnaire

Component	Interpretation
1	Teachers' beliefs about their own ability to use IBI.
2	Teachers' beliefs about the adequacy of IBI for their students.
3	Teachers' beliefs about the availability of resources to teach IBI
4	Teachers' beliefs about the adequacy of social support for their practice of IBI.

2.3.3 Internal Consistency Reliability of the Questionnaire

Reliability testing using SPSS was performed for each of the sections of the pilot tested questionnaire, and also for all the sections combined. The Cronbach alphas obtained for each section, as well as all the sections combined were used to assess the internal consistency reliability of the questionnaire.

2.3.4 Validity and Reliability of the Observational Rating Scale

The observational rating scale was already subjected to thorough checks for face, content and construct validity as well as inter-rater reliability. It was deemed unnecessary to revalidate this rating scale for the population for this study because the rating scale measures an approach to instruction (IBI). This approach is based on specific criteria and guidelines put forward by organizations such as the AAAS (1989) and the NRC (1996). These guidelines are the basis for all underlying dimensions of the rating scale and are constant regardless of the population of teachers being examined.

All the assessments were conducted by the lead researcher. There was therefore no need for any inter-rater reliability procedures. However the researcher did some preliminary assessments using two teachers from district 1. This was in order to develop the necessary expertise in using the instrument. Prior to these assessments, the lead researcher followed a webinar on the use of EQUIP hosted by Robert Horton on the EQUIP website ("Inquiry in motion", 2007).

Intra-rater reliability was assessed during the lesson observation phase of the study. Two video recorded lessons were obtained. The first was a grade 3 lesson obtained from a fellow researcher. The lesson was recorded in a school and classroom forming part of this research. The second lesson was from a grade 5 class and recorded by the lead researcher during the lesson observation phase of the study. Each lesson was assessed by the researcher three times over a two week period, each of the two final assessments being done one week after the previous one.

Based on the consistency between the assessments, the researchers deemed that the intra-rater reliability for the lesson observation assessments was satisfactory.

2.4 Data Analysis Procedures

2.4.1 Scoring for the Questionnaire Responses

Responses for each item of the Likert scales were coded so that a score of 5 represented the belief that was most favourable to IBI practices and a score of 1, the belief that was most unfavourable to IBI practices. This was done for each belief construct. There was therefore reverse scoring for the negatively worded items.

The score obtained by each participant for each item in sections B and C of the questionnaire was entered into SPSS 18. The mean scores for all the participants for each belief construct were obtained to determine the level of primary school teachers' beliefs related to IBI. The mean score was interpreted as shown in table 5.

Table 5. Interpretation of mean score for each belief construct

Range of mean belief score	Level of belief
1.00– 2.04	Very unfavourable for IBI
2.05-3.04	Unfavourable for IBI
3.05-4.04	Moderately favourable for IBI
4.05-4.50	Favourable for IBI
4.51-5.00	Very favourable for IBI

For a more in-depth analysis, the mean scores of all the participants for each of the underlying factors of the belief constructs were also obtained and interpreted as in table 5.

For the lesson observations, each teacher in the sample received a score ranging from a minimum of 5 to a maximum of 20. The teachers in the sample were identified and their scores entered in the appropriate row of the SPSS data sheet. The mean rating of all the teachers in the sample was obtained and the scores interpreted as shown in table 6:

Table 6. Interpretation of scores for lesson observation

Range of scores	Score interpretation
5.0–9.0	Pre-inquiry
9.1–13.0	Developing inquiry
3.1–17.0	Proficient inquiry
17.1–20.0	Exemplary inquiry

The interpretation of the scores were based on the assessment scales used in the EQUIP instrument used for the lesson observation.

Multiple regression analyses were used to determine how teachers' level of each of the belief constructs, jointly and independently predict their level of IBI.

3. Results

Out of the sample of 341 teachers for the survey administration, 302 questionnaires were collected and analyzed, a response rate of 88.6%. The overall reliability of the questionnaire was found to be 85.5%. The reliability of the beliefs about science teaching and learning inventory was 76.5%, and for the applicability belief inventory, 76.6%.

3.1 Analysis for Research Question 1

Table 7 shows the overall mean for each belief construct for all the teachers in the sample. The maximum possible score is 5.

Table 7. Level of teachers' beliefs

Belief	Mean score /5	Interpretation
Science teaching and learning	4	Favourable
Applicability	3.5	Moderately favourable

The findings indicate that the applicability beliefs of the sample were only moderately favourable towards IBI practices. The beliefs about science teaching and learning were generally favourable.

3.1.1 Teachers' Beliefs about Science Teaching and Learning

Table 8 below shows the frequency distribution of teachers' beliefs scores about science teaching and learning scores.

Table 8. Frequency distribution of teachers' belief scores about science teaching and learning

Science teaching and learning mean belief score	Frequency	%	Cumulative %	Interpretation
1.00-2.04	0	0	0	Very unfavourable
2.05-3.04	1	0.3	0.3	Unfavourable
3.05-4.04	154	51	51.3	Moderately favourable
4.05-4.50	121	40.1	91.4	Favourable
4.50-5.00	26	8.6	100	Very favourable

The results show that the large majority of teachers (99.7%) have beliefs about science teaching and learning that are moderately favourable, favourable, or very favourable to the practice of IBI. However, the beliefs of more than half of the teachers (51%) are only moderately favourable.

The mean for each of the underlying constructs for teachers' beliefs about science teaching and learning are shown in table 9.

Table 9. Means for underlying constructs for beliefs about science teaching and learning

Sub-Construct	Mean score /5	Interpretation
Mode of instruction.	4.3	Favourable
Manner of delivery of science content	3.5	Moderately favourable
Provision of instructional factors	4.1	Favourable
Student engagement in instructional activities	4.6	Favourable
Student engagement with the science content	3.9	Moderately favourable

The findings indicate generally favourable scores for all the belief sub-constructs except for teachers' beliefs about the manner in which they should present science content to students, and teachers' beliefs about the manner in which students should engage with the science content. These obtained only moderately favourable scores towards IBI.

3.1.2 Teachers' Applicability Beliefs

Table 10 below shows the frequency distribution for teachers' applicability beliefs.

Table 10. Frequency distribution of teachers' applicability belief scores

Mean applicability belief score	Frequency	Percentage	Cumulative percentage	Interpretation
1.00-2.04	0	0	0	Very unfavourable
2.05-3.04	98	32.5	32.5	Unfavourable
3.05-4.04	194	64.2	96.7	Moderately favourable
4.05-4.50	7	2.3	99.0	Favourable
4.50-5.00	3	1.0	100	Very unfavourable

The findings indicate that the large majority of teachers (96.7%) have applicability beliefs that are either unfavourable or moderately favourable to their practice of IBI. Almost one third of the teachers (32.5%) have applicability beliefs unfavourable to their practice of IBI.

The mean for each of the underlying constructs for teachers' applicability beliefs are shown in table 11.

Table 11. Means for underlying constructs for teachers' applicability beliefs

Sub-Construct	Mean score/5	Interpretation
Personal ability to use IBI	3.5	Moderately favourable
Suitability of IBI for students	3.8	Moderately favourable
Adequacy of available resources for IBI	2.9	Unfavourable
Adequacy of social support for IBI	2.7	Unfavourable

The findings reveal only moderately favourable scores for teachers' beliefs about their personal ability to use IBI and also their beliefs about the adequacy of IBI for their students. In contrast, the scores for teachers' beliefs about the adequacy of available resources for IBI and for their beliefs about the adequacy of social support for IBI were unfavourable.

3.2 Analysis of Research Question 2

The overall mean obtained for the inquiry-based instructional strategies of the teachers in the sample was 12.0. Based on the researchers interpretation of these scores shown in table 9, the teachers instructional practices in science can generally be rated as developing inquiry. Table 12 below shows the frequency distribution of the IBI scores for the teachers in the lesson observation sample.

Table 12. Frequency distribution of teachers' IBI scores

IBI scores	Frequency	Percentage	Cumulative percentage	Inquiry level
1.00- 9.00	8	9.4	9.4	Pre-inquiry
9.01-11.00	17	20.0	29.4	Developing inquiry
11.01-13.00	31	36.5	65.9	Developing inquiry
13.01-15.00	25	29.4	95.3	Proficient inquiry
15.01-17.00	3	3.5	98.8	Proficient inquiry
17.01-20.00	1	1.2	100	Exemplary inquiry

As seen in the table, almost two-thirds of the teachers (65.9%) practice a level of IBI that is at either the pre-inquiry or developing inquiry level. 32.9% practice IBI at the more acceptable proficient inquiry level, and only one teacher practices IBI at the exemplary inquiry level.

For a more in-depth analysis of teachers' inquiry-based instructional practices, the mean score obtained by the sample for each component factor was measured. These are shown in table 14.

Table 13. Mean score for component factors of IBI practices

Factors	Mean score /20	Interpretation
Instructional factors	13.44	Proficient inquiry
Discourse factors	12.02	Developing inquiry
Assessment factors	12.22	Developing inquiry
Curriculum factors	10.55	Developing inquiry

The findings therefore indicate that while the sample generally functioned at the proficient inquiry level for their science instructional processes, they only functioned at the developing inquiry level for teaching processes related to their discourse with students, their assessment of students, and various curriculum related factors.

3.3 Analysis of Research Question 3

3.3.1 Independent Regressions

Table 14 below shows the results of the analysis for the independent regressions with the predictor variables being each belief construct, and the criterion variable being the IBI scores.

Table 14. Independent regression analyses for teachers' beliefs and IBI practices.

Belief	R	Adjusted R squared	F1,83	Sig
Science teaching and learning	.416	.173	17.405	.000**
Applicability	.301	.079	8.252	.005*

*significant (p<.01) **significant (p<.0005)

The analyses indicate that both regressions are significant beyond the .05 level. The regression coefficient is highest for science teaching and learning beliefs (.416), indicating that this belief construct is the strongest predictor of teachers' inquiry based practices. The R squared value of 17.3% also suggests a large effect size. The effect size shows that 17.3% of the variance in teachers IBI practices could be accounted for by changes in this belief construct. On the other hand, the applicability belief construct has a small effect size (7.9%). This belief construct also recorded the moderate regression coefficient of .301.

Independent regressions were also conducted to determine the extent to which the two belief constructs predict each of the component factors of teachers' IBI. Only teachers' beliefs about science teaching and learning were found to be significant predictors of three of the component factors of teachers' IBI. These were the instructional factors related to IBI ($R=.381$, Adj $R^2=.135$, $p<.0005$), teachers' assessment processes related to IBI ($R=.375$, Adj $R^2=.131$, $p< .0005$), and curriculum factors related to IBI ($R=.387$, Adj $R^2=.139$, $p< .0005$). All the regressions are moderate and positive.

4. Discussion

4.1 Teachers' Beliefs about Science Teaching and Learning

Teachers' beliefs about science teaching and learning were found to be favourable towards their IBI practices. This may seem surprising considering the poor performance of secondary school students in science and the prevailing perception that many primary school teachers have poor backgrounds and attitudes to science. However when one considers the nature and origin of these beliefs, the favourable beliefs of teachers may not be that surprising. Levitt (2001) attributes these beliefs to accumulated images of an individual's experiences with learning science in the formal school system. For trained teachers, these experiences would also include the years of pedagogical training. For many of these teachers, the experiences of secondary school science were not good. The experiences of teacher education however, were more recent and obviously more relevant to their practices as science teachers. So when one considers the experiences of teacher education, then the favourable scores may not be all that surprising.

If we accept the view of Rokeach (1968), as cited by Pajares (1992) that beliefs have a cognitive component representing knowledge, and an affective component arousing emotion, it can be argued that teachers' beliefs about science teaching and learning have more of a knowledge component and less of an affective component than their applicability beliefs. While there are significant personal feelings associated with applicability beliefs, this is less the case for beliefs about science teaching and learning where the cognitive component is more significant. The knowledge gained during teacher education should form a significant aspect of teachers' beliefs about the subject matter. Hence these beliefs regarding science teaching and learning may actually favour the IBI practices learnt during teacher education.

The favourable score of teachers' beliefs about science teaching and learning was due to three of the underlying constructs. One of them was the favourable teachers' beliefs about the mode of instruction that would best facilitate student learning of science content. Chai, Teo and Lee (2009) described this underlying construct as forming a continuum between teaching as a process of knowledge transmission on one end, and teaching as facilitating students' construction of knowledge at the other end. So the favourable score indicates that teachers, beliefs about the instructional mode that would best facilitate learning of science content may actually lie somewhere nearer the facilitating of knowledge construction than the transmission of knowledge. The lesson observations and IBI scores obtained in this study also bear testimony to this.

The second underlying construct which contributed to the teachers' favourable scores about science teaching and learning was teachers' beliefs about their role in the provision of instructional factors. An important requirement of IBI is that students must be provided with adequate time and resources to actively engage in the learning of science content. Munby (1984) linked this to teachers' beliefs when he advocated that the treatment that novel instructional materials receive by teachers are linked to their beliefs about what it means to be a science teacher as well as how teaching should be conducted. Even though Munby's focus was on novel instructional materials, this is appropriate to this discussion when one considers that for IBI, teachers have to constantly respond to changing curricula focuses by searching for and selecting appropriate materials. With regards to the provision of adequate time, this is less under the control of teachers since the time table is set by the school administration. However, as demonstrated by some teachers in this study, teachers are able to do some minor alterations to the time table where they deem it necessary to increase or decrease the time allowed for certain subject areas. Two of the most effective lessons seen by the lead researcher were when teachers altered the time table to allow a science block of three 30-minute lessons in one morning.

The third underlying construct which contributed to the teachers' favourable scores about science teaching and learning was teachers' beliefs about the way they should engage students in instructional activities. This ranged from students simply being engaged in receiving information from teachers; to students being actively engaged in inquiry-based activities such as searching for information, problem solving, manipulating materials and equipment etc. So this construct actually complements the first underlying construct of teachers' beliefs about the mode of instruction that would best facilitate student learning of science content.

Two of the underlying constructs of teachers' beliefs about science teaching and learning received only moderately favourable scores. The first is teachers' beliefs about the manner of delivery of science content. This ranges from the simple belief of a purely didactic mode of instruction to one where the teacher merely acts as a facilitator to the student learning of science content. The second is teachers' beliefs about the way students should engage in the learning of science content. This ranged from students passively accepting the science content presented to them to students being more critically minded in their engagement with the science content. These two constructs differ from the others in that they are particularly focused on the presentation and learning of science content. The moderately favourable scores may therefore be related to the perceived lack of adequate science content by primary school teachers.. A lack of knowledge of the science content to be taught would prevent teachers from adequately engaging students in the kind of instructional strategies required by IBI and instead rely on didactic methods of instruction.

The favourable beliefs of the teachers in this study about science teaching and learning should be of comfort to education authorities since researchers have linked these beliefs to effective teaching. For example Jones and Carter (2007) concluded that beliefs about science teaching and learning do affect the type of instructional behaviours of science teachers. Levitt (2001) had also postulated that, teachers' beliefs about the teaching and learning of science is a strong determinant of the science education experiences of children.

4.2 Teachers' Applicability Beliefs

The findings of this study revealed that teachers' applicability beliefs were only moderately favourable towards IBI. This relatively low score is an indication that teachers do have concerns that the schools' physical and social environments, as well as personal issues related to the provision of resources for IBI, and confidence using IBI, are not very conducive to their IBI practices. Both Fang (1996) and Jones and Carter (2007) had alluded to the possibility that various constraints posed by the complexities of the school and classroom setting may impede teachers in applying their beliefs related to teaching and learning. Evidence for this can also be seen when the teachers, belief scores for the underlying constructs of applicability beliefs are examined. Two of the sub-constructs actually received unfavourable belief scores towards IBI. These were teachers' beliefs about the adequacy of social support for IBI, and teachers' beliefs about the adequacy of available resources for IBI.

These findings are important in that, firstly, they are an indication that teachers generally believe that the social environments of their schools, which includes their relationships with the school administration and other teachers, are not conducive to their use of IBI practices. So either they believe that they are not being supported in their use of IBI, or they are faced with situations in the social environment that actually act against their use of IBI. Marshall et al (2007) and Deemer (2004), commenting on the institutional support for IBI received by teachers, indicated that the level of social support is influential in how efficiently teachers' implement IBI.

The second importance of these findings is that teachers are of the belief that they either have difficulty obtaining materials, or they are not provided with adequate materials and resources to effectively use IBI. This probably points to a misconception in many teachers that was brought up by Levitt (2001) when he claimed that many elementary school teachers believe that the teaching of science requires the sophisticated equipment found in secondary school laboratories. However the possession of this misconception may actually deter teachers from effectively using manipulative activities in their science lessons. Plourde (2002) also noted this but added that teachers who do use these activities must often pay for the needed materials and equipment. This has also been noted by the lead researcher for teachers in the area under study. This also raises issues about the teacher education process, specifically that student teachers may not be adequately encouraged to adapt easily available and relatively cheap materials for their science lessons.

Apart from materials and equipment, there is the time required to effectively teach science using IBI. This is an area of concern for the study population based on the researchers' observation that most schools have only two science lessons per week for all their classes. In addition, many of the schools do not have a double period for science which is probably the minimum requirement for effective activity-oriented instruction. Of added concern is the inequality in the time allocation for science in the various schools as well as the researchers' observation that the majority of schools have science either late in the morning or afternoon. A fundamental requirement for IBI is the allocation of adequate time for students to meaningfully engage in the recommended activities. Other researchers, such as Abd-el Khalick et al (2004), Jones and Carter (2007), Levitt (2001) and Plourde (2002), have found similar perceptions by teachers of a lack of adequate time for science instruction.

The other two underlying constructs of applicability beliefs received only moderately favourable scores towards IBI. These were teachers' beliefs about their personal ability to use IBI practices, and teachers' beliefs about the adequacy of IBI for their students. The first again raises issues about the teacher education process since it is during the years of teacher education that primary school teachers are exposed to and practice the use of IBI. It is a fair argument to question whether the two years of primary teacher education, in which student teachers are engaged in a number of courses and activities in various subject areas, are indeed adequate to prepare them to use IBI in the classroom. Researchers have also pointed to teachers' lack of confidence teaching science using IBI (e.g. Abd-el-Khalick et al, 2004), their lack of comfort using IBI (e.g. Ibrahim, 2003), and even a lack of understanding of what constitutes IBI (Abd-el-Khalick et al, 2004).

The second construct probably has to do with the reactions and performance of students when exposed to IBI. There are a multitude of factors that may cause students not to respond positively to these strategies. They include teachers' own ability to manage students in these IBI classrooms as well as students being accustomed to the traditional ways of instruction. However, Ibrahim (2003) cited research indicating that IBI was not appropriate for slow learners (Victor, 1989) or for students like those in elementary school without a good science background (Gagne, 1963; Victor, 1989). These are very applicable to the mixed ability primary school classroom situation in St. Lucia.

4.3 Teachers' IBI Practices

The findings of this study are similar to the findings of many studies around the world that examined the level of IBI practiced by teachers of elementary school science. These studies reported that, despite the curricula emphasis on inquiry, the majority of teachers still mainly resorted to the traditional content-focused instructional strategies in their teaching of science (e.g. Abd-el-Khalick et al, 2004; Anderson, 2002; Jones and Carter, 2007; OECD, 2009; Plourde, 2002). The findings of this study also justify to a large extent the concerns that have been expressed by science curriculum officers and science educators about the low level of teachers' IBI practices. The mean score obtained by the teachers, supported by the researchers own general observations, suggests that the majority of teachers generally teach at the developing inquiry level.

The frequency distribution of IBI scores justifies even further the reason for concern since 13.3% of the teachers teach at the pre-inquiry level. It is indeed worrying that only 35.5% of the sample taught at the recommended proficiency inquiry level while only one teacher taught at the exemplary inquiry level. The problems being experienced with poor attitudes and interest of students in science may therefore have their origin in primary science education. An examination of the specific areas of weakness in the implementation of IBI may be instructive.

When the teachers' scores in the component factors of IBI are examined it can be seen that the sample actually scored at the proficient inquiry level for instructional factors. This means that generally, teachers do make the attempt at student-centered teaching strategies, acting as a facilitator to the students' learning of science content. The developing inquiry level that the teachers scored for discourse, assessment and curriculum factors indicates that the areas of deficiencies in teaches' IBI practices are in questioning and discussion, the stimulation of student critical thinking, assessment techniques and in the depth of content and activities planned for the students.

4.4 Teachers' Beliefs and Their IBI Practices

The findings of this study indicate that each of the belief constructs is a significant and moderate predictor of the IBI of the teachers in the population, with teachers' beliefs about science teaching and learning being the stronger predictor. However, this was the only of the two belief constructs in which teachers generally received scores favourable to their IBI practices. In a way, these findings contradict those of researchers such as Levitt (2001) who maintained that pedagogical content knowledge beliefs are strongly linked to teachers' classroom practices. The contradiction lies in the findings of this study of fairly low levels of teachers' IBI practices in science compared to their favourable beliefs about science teaching and learning. In that sense therefore, teachers' IBI practices generally do not reflect their beliefs about science teaching and learning. The findings however, also show that these beliefs do predict, albeit moderately, the level of teachers' IBI practices. The researchers have already theorized that the favourable beliefs about science teaching and learning, compared to the other belief construct, are due to the teacher education experiences of teachers. Yet these favourable beliefs are not reflected in the level of teachers' IBI practices. But it does seem that the higher the favourability of teachers' beliefs about science teaching and learning the more likely they are to practice a higher level of IBI.

With regards to the component factors of IBI, teachers' beliefs about science teaching and learning were found to be moderate and positive predictors of their instructional processes, their assessment strategies and their attention to curriculum factors supporting IBI. So this study does reveal the link, as suggested by Levitt (2001), between these beliefs and many aspects of the teaching process in primary school science. However, despite this predictive ability, this belief construct seems to substantiate the views of many researchers (e.g. Cain, 2009; Pajares, 1992; Saker, 2010) that the beliefs of teachers are not adequately reflected in their teaching practices. The important question is, why should that be the case for this belief construct and not the other? The researchers have made the assertion that teachers' current beliefs about science teaching and learning develop as a result of their teacher education experiences and have more of a knowledge component than an affective one. If this is the case, then the argument can also be made that these beliefs should have less an impact on teachers' classroom behaviours than their applicability beliefs.

The applicability belief construct was the only one that was shown by this study as not being a significant predictor of teachers' IBI practices. This was because the effect size was less than 0.1 showing that less than 10% of teachers' IBI practices can be predicted by their applicability beliefs. This result complements the findings on the level of teachers' beliefs where teachers' applicability beliefs recorded the lowest favourability score, and two of the underlying constructs actually recorded unfavourable scores towards teachers' IBI practices. It also substantiates the findings of a number of researchers such as Brouwer and Korthagen (2005), Deemer (2004), Fang (1996), Jones and Carter (2007), and Marshall et al (2007), that teachers' perception of various social, psychological and environmental constraints can significantly impede their practice of IBI. This impedance is to an extent that, as shown by this study, teachers' applicability beliefs cannot safely be used to predict their level of their IBI practices.

It therefore has to be emphasized that even though regression analyses did not reveal that teachers' applicability beliefs are adequate predictors of their IBI practices, this is not necessarily contrary to the findings of researchers that these beliefs can actually impede teachers' IBI practices. The findings of this study actually seem to corroborate these findings since applicability belief scores were the lowest of the belief constructs, which seemed to be reflected in the low IBI scores of the majority of teachers. So interventions targeted at improving teachers' level of IBI in science must involve addressing these low applicability beliefs, especially the underlying constructs which received unfavourable scores. These are teachers' beliefs about their social support for IBI and their beliefs about the availability of resources for IBI.

4.5 Conclusions

Based on the findings the following conclusions can be drawn:

1) The generally low levels of IBI measured from the majority of teachers in the sample substantiate the claims of science educators and science curriculum officers over the last few years of inadequate levels of IBI in primary school science.
2) The mean areas of weakness in the IBI of teachers in the sample were in their level of inquiry-related discourse, assessment, and attention to curriculum factors. On the other hand, the student-centeredness of teachers' instruction was generally found to be at a satisfactory level.
3) The teacher education process as well as in-service professional development activities has not been sufficiently effective in enabling IBI in the science lessons of primary schools in St. Lucia.
4) It is also the strong belief of teachers that they do not receive adequate support from the school authorities to implement IBI In their science lessons. This is especially the case for the provision of material resources, as well as social support from education officers, principals and fellow teachers.
5) Teachers' beliefs about science teaching and learning can be regarded as significant predictors of their IBI practices in science. Teachers with the more favourable beliefs towards IBI should generally be expected to practice higher levels of IBI.
6) Evidence from this research supports, on the one hand, findings by several researchers of a strong link between teachers' beliefs and their classroom practices. This was primarily seen in the generally low levels of teachers' applicability beliefs. On the other hand, evidence from this research supports the contrary findings of other researchers that teachers' beliefs do not find reflection in their classroom practices. This was with regards to the findings of the generally positive beliefs about science teaching and learning not being reflected in a high level of IBI practices.
7) Primary school teachers are of the strong belief that the social environment at their school, as well as the availability of resources for IBI (including time) is not conducive to their practice of IBI.

4.6 Recommendations

Since it is currently accepted that the preferred method of meaningfully engaging students in science is through IBI, then the findings of inadequate levels of IBI in the science instruction of primary schools in St. Lucia warrants immediate attention and intervention by the education authorities. The following are therefore recommended:

1) A thorough examination of the teacher education science curriculum is recommended, with subsequent interventions to address the possible inadequacies in its implementation that may result in the inability of teachers to effectively implement IBI.
2) There needs to be a greater level of monitoring of the implementation of the primary school science curriculum, especially the actual teaching of science. This should have the dual purpose of determining the extent to which teachers conform to the requirements of the curriculum as regards their teaching methods, as well as to observe firsthand the school factors affecting teachers' IBI practices.
3) Key areas of IBI weaknesses of teachers IBI practices revealed by this study are their questioning techniques that would stimulate discussion and critical thinking, the use of both formal and informal assessment techniques in their science lessons, the depth at which they expose students to the content being taught, and the use of inquiry-based activities relevant to the content being taught. These are probably areas where teachers need some further enlightenment through professional development activities.

4) With regards to teachers' beliefs, the findings that one belief construct is a significant predictor of IBI practices, while the other is most likely the reason for the low levels of IBI in primary schools, mean that attention need to be paid to the factors leading to the development of these beliefs. Since the teachers' formal educational experiences are the factors that educational authorities can have some control over, then the following are recommended:

   - Teachers concerns about their physical and social environments not being conducive to their practice of IBI should be urgently tended to since this study indicates that this, to a large extent, is responsible for the low levels of IBI in primary schools. This is especially the case for their social support for IBI and the availability of materials for IBI. .
   - Teachers' belief about the lack of available time to teach science is a relevant but troublesome issue to deal with. The reasons for this are related to the perceived large amount of time which needs to be devoted to language arts and mathematics in the school curriculum. One solution to this is the training of teachers in the integration of the curricula of different subjects. In addition, it should be mandated that all schools have a double period every week for science. There also needs to be a bit more flexibility allowed in the class timetables so teachers can adjust the time for particular subjects when needed.

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