A survey of
Science in government primary schools
in the Cayman Islands

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Executive Summary

Background to the survey

This survey into the quality of provision for the teaching of science in government primary schools in the Cayman Islands was commissioned by the Education Standards and Assessment Unit of the Cayman Islands . The purposes of the survey are:

- To evaluate and report on the quality of provision for science in government primary schools, including an evaluation of strengths and weaknesses in:
    - The standards that students are achieving in all aspects of science
    - The quality of teaching and learning
    - How well the subject is coordinated, led and managed
    - How well prepared schools are to implement the 2008 national curriculum for science and design technology
    - The quality of resources and accommodation available in primary schools for learning science
- To make recommendations for improving the provision for science in government primary schools
- To identify good practice where it exists

The survey was carried out by Jim McVeigh and Roger Holmes, both of whom are schools' inspectors with considerable experience of science education in the Cayman Islands and the UK.

Evidence Base

The survey drew on the following evidence:

- Lesson observations in all but two government primary schools
- Discussions with principals, science coordinators, teachers and students in all of the primary schools
- Scrutiny of documentation, including schemes of work and teachers' planning sheets
- End of key stage test results and schools' internal examination results
- Meetings with learning community leaders and the head of curriculum services
- Discussions with the head of science at the George Hicks campus and the examinations and assessment officer in the Department of Education Services
- An assessment of the impact of equipment and resources on the quality of science provision and needs of the new national curriculum.

Main Findings

Overview

Results in primary science are rising, often as a result of individual teachers' efforts and commitment, but they are still too low and the overall quality of provision is inadequate. Teaching in science is very varied. Students, in some lessons, receive a rich and stimulating experience in science as a result of effective, enthusiastic teaching, but too many lessons focus on memorizing facts rather than understanding the process of science. Overall, students are not given enough opportunities to think scientifically, raise questions or investigate for themselves. The shortfalls in primary science education have been recognized by the head of curriculum services, several individual teachers and some schools, but, at the moment, there is no strategic plan to address this issue. Resources and accommodation are adequate, but the overall effectiveness of science teaching is not. Plans to focus on generic teaching and learning strategies may help to improve students' achievement in science. However, these plans need to include elements that focus on issues specific to science and technology, such as subject knowledge, scientific methodology and management of practical activities, if achievement is going to match internationally expected standards.

Students' achievement and progress

- Students are enthusiastic and enjoy science.
- Only about 40 percent of students reached the expected levels of achievement in the 2007 key stage tests. This was better than in earlier years but still well below the comparable figure of 87 percent in UK. Students perform best when recalling facts and worst when asked to investigate and to reason scientifically.
- Progress in lessons is often limited by slow pace and by the introduction of misconceptions.
- Progress over time is limited by the current organization of the curriculum, which leads to the repetition of some topics and omission others.

The quality of teaching and its impact on learning

- The quality of science lessons is very variable, often within the same school, reflecting a lack of clear guidance on what constitutes effective science teaching.
- Some teachers place an appropriately strong emphasis on inquiry but many teachers are not confident in teaching science this way. They rely heavily on the text book and focus on teaching facts rather than understanding.
- Teachers' own science understanding is often limited and this leads to them passing on misconceptions to their students.
- Many teachers are reluctant to undertake practical activities and lack experience and expertise in managing such activities safely and effectively.
- Some teachers are very enthusiastic about science and encourage their students to raise questions and search for solutions. Their lessons are lively and stimulating, with very good general questioning and fruitful discussion. Their students develop very positive attitudes to science and a good overall grasp of the scientific process, but even in these classes, misconceptions remain unchallenged and opportunities for investigations are missed.
- There is little effective differentiation and it is the more able students are not challenged enough.

- Some teachers find that science stimulates some of their students who perform poorly in other subjects, and gives them the chance to shine.
- In some lessons, there are good links to literacy, through the use of texts, poems and key word lists, but scientific vocabulary is rarely added to word walls.

Organisation and management

- In schools, principals have been encouraged to focus on literacy and, as a consequence, science has not received enough attention.
- Schools generally follow the requirement to have two hours of science per week on the time table for each class. This is an appropriate time allocation.
- The Education Department has given guidance for teaching science to schools by providing a curriculum, and a recommended series of textbooks, which have their own associated activity kits. There is also an outline curriculum map that identifies which sections of the textbooks are relevant to the curriculum. There has been no guidance on how to teach science.
- The effect of stressing the importance of the textbooks in science teaching has been to put too much emphasis on the knowledge aspects of science at the expense of inquiry.
- The guidance tells schools which topics to cover each year but does not explain what level of complexity is expected. As a result, students often meet the same material year after year.
- Schools following the textbook find that they have too much to cover and are unable to finish all of the topics in a year. Because the topics are followed in the same sequence, students meet the biological topics repeatedly at the start of each year and often do not get as far as the physics related topics that come later in the sequence.
- Most schools have designated science coordinators to manage the science curriculum and many of the coordinators are keen to develop their own science expertise further and become more effective in their role. Science coordinators have not been given any professional support and have not been helped to establish networks to share ideas.
- Schools or individuals do not have membership of professional organizations for science teachers, such as the National Science Teachers' Association (NSTA), and the Association for Science Education (ASE), which would help them improve the quality of science provision.
- Schools are not able to call on professional guidance locally which combines the three elements necessary for good science teaching; effective pedagogy, sound knowledge of science and an ability to help students develop their scientific investigation skills.

Science key stage tests

- The tests set at the end of each key stage provide a valid measure of students' performance but are not being used well enough by schools as a way of raising performance.
- Questions in the tests often require students to apply science concepts in new situations and to understand the process of scientific inquiry, whilst tests set by schools, often taken from the Harcourt text books, mainly measure the ability to recall facts. Consequently, students perform differently in the school tests and the key stage tests.
- The key stage tests are seen by many schools as being too hard and are blamed for the students' low scores, rather than being used to improve teaching. Also, the low student scores are used by the middle school to make the unhelpful overall judgment that students are not very good at science.

- Schools do not see the key stage test papers after they have been marked and so do not have the opportunity to analyse their students' performance. Only one school has recognized the need to revise the way it teaches science to make sure that its students are ready for the key stage test.

Preparations for the new national curriculum

- Schools welcome the new curriculum for science. They also value the introduction of national curriculum levels described by performance criteria and recognise that teachers will need support in using the levels effectively.
- Some useful networks are being developed amongst schools, for example, the Eastern District and Creek and Spot Bay Primary School linking together for IB planning.
- There are outline plans to improve teaching and learning. These plans often include elements specific to literacy, but, as yet, there are no plans to address issues specific to science teaching.

Recommendations

The Department of Education Services should work with schools in order to develop a strategic plan to improve science provision. The plan should be linked to the introduction of the new national curriculum so that support for using the new programmes and assessment instruments meets the needs for improved organization and pedagogy identified in this survey. The plan should include elements that:

- Raise awareness of the low level of performance in science by ensuring that schools report students' levels of achievement alongside the levels expected for their age

- Use the key stage tests more effectively to raise standards of achievement. Return marked papers to the schools, together with an examiner's report highlighting students' strengths and weaknesses. Learning community leaders should work with their schools to analyse their performance and produce plans for improvement, which include agreed targets for students' achievement and suitable time-lines.

- Provide guidance to schools on how to teach science in order to meet the requirements of the national curriculum. This guidance should include clarification of the depth of study appropriate at different stages of education and suggested teaching approaches that stress inquiry and student involvement.

- Develop teachers' skills in teaching science. This will involve enhancing their own science knowledge, helping them to manage practical activities effectively and providing a scientific slant on the inquiry-based approach that will be developed for IB. A coaching model is likely to be most effective for this, with science lead-teachers working in all schools. A first step would be to identify potential lead teachers who are strong on pedagogy with an effective approach to inquiry and provide on-going training which strengthens their science understanding and also provides them with the skills to work with other teachers.

- Establish networks for science teachers to encourage the exchange of ideas, raise their confidence and help them to enjoy teaching science.

- Make use of membership of professional bodies to support teachers by providing ideas for effective approaches to teaching particular topics, guidance on issues such as safety, and information about new resources.

- Establish links between primary and middle schools to share assessment information and to exchange ideas for teaching. This would be a two way process from which both sectors would benefit.

Commentary

Standards achievement and progress

Students do not achieve well in the end of key stage tests that they take in Year 6. The average mark was 33 percent in 2006 and 35 percent in 2007. They tackle questions about biology much better than other aspects of science. For example, the mean score for a question in 2007 which asked about life processes and diet, was a respectable 69 percent. On the same paper, the average score for one question, which asked students to plan an investigation, was only 19 percent, and on another question, which asked students to use their understanding of simple electrical circuits in an unusual context, the average score was even lower - at 9 percent. Clearly, students are much better at some aspects of science than others.

This difference is also evident in lessons and in students' responses to questions. Students are most confident in answering straightforward factual questions; for example, naming Mercury as the planet nearest to the sun. They have much more difficulty in making use of their scientific knowledge in new situations. For example, a group of Year 6 students simply accepted the fact that Venus is hotter than Mercury although it is further from the sun. They did not question this apparent anomaly and, when it was pointed out to them, they found it very difficult to suggest any possible explanations, although they had heard about the greenhouse effect of the Earth's atmosphere and knew that Venus is surrounded by gas.

Students enjoy the practical work involved in science. This aspect of the subject is one of the main reasons that students say they enjoy science. The demonstrations that they see and the experiments that they carry out, help to illustrate and enliven the science that they are learning and to make it more memorable. In these practical activities, they observe reasonably accurately and appreciate the importance of recording their results. Much of the practical work that students carry out is carefully controlled, often following a set of instructions. As a result, many students do not develop the ability to design and carry out their own investigations and are not sure how to ensure that a test is fair.

The progress that students make in lessons is sometimes limited by the teacher trying to spread too little material over too long a period of time. One example of this was when Year 1 students were given 15 minutes to draw the seeds that they saw in a sliced apple onto an outline that had already been prepared for them. A group of students with special educational needs made much better progress in a lesson with similar aims because they had a much richer range of activities, including watching a time-lapse video of seeds growing.

Students' progress over time is restricted by the way that the curriculum is organized in many schools. Teachers are given a list of topics to be covered in the year but are not helped to decide on the detail or depth of coverage for each topic. Many teachers, very understandably, make use of the text book, which often contains much more detail than is needed for the grade level. Covering this unnecessary detail takes time and means that topics later in the list have to be rushed or are not reached at all. Because of the way the text book is organized, the topics that are left to last and skimped are often the physical sciences.

Key stage tests

The key stage tests are an important feature of primary science teaching in Cayman. The tests are taken towards the end of Year 6 and, until 2007, at the end of Year 3. They are intended to measure students' attainment over the key stage, so the Year 6 test covers the science taught in Years 4, 5 and 6. Students perform badly in the tests and schools do not believe the test results are reliable because they are so much different from their own assessments of how good their students are at science.

The key stage tests are well-written, with questions that require the students to apply the science that they have learnt in new situations, to explain why events occur and to show that they understand the process of scientific investigation. Very few marks can be earned by recalling facts alone. In many of the questions, students have to write a few words of explanation.

When schools assess students themselves, they frequently use questions from the text books. These questions very often ask students simply to recall facts and to choose between alternative answers rather than to make an extended written response. With such differences in what is being tested and how students are expected to respond, it is not surprising that the outcomes are so far apart.

Far too little use has been made of the test results to identify weaknesses in the way science is taught and to find ways to compensate for them. Schools receive the results of the tests, but little has been done to explain what they mean about students' capabilities in science or the relative effectiveness of schools in raising students' achievement in science. Schools do not get their students' papers back after they have been marked and so they cannot analyse the answers to see where they have performed well and where poorly. Similarly, schools have not been encouraged to examine the sorts of questions that are used in the tests, so they are not made aware of the emphasis being placed on application of science and on investigations. These are important missed opportunities to help teachers come to understand the style of science education that the national curriculum represents.

A further negative outcome of the tests is that the low results are seen by the secondary schools as showing that the students coming to them cannot do science well. This unhelpful generalization ignores the aspects of science that students from the primary schools are good at, and overlooks the significant proportion of students who do reach the expected levels of achievement despite the shortcomings in the system.

The quality of teaching and its impact learning

There was a very wide range in the quality and effectiveness of the science teaching seen during the survey. There was even considerable variation between lessons for parallel classes of the same year group in the same school. This situation reflects the absence of a clear understanding of what is expected of a good science lesson, rather than teachers' unwillingness to improve.

Some teachers are very enthusiastic about science. They go to considerable trouble to learn more about the topics that they are teaching and search for ways to make their lessons stimulating and effective, often using the internet as a source of ideas. These teachers often

have an overall approach that encourages students to raise questions and search for solutions rather than simply accept information. They make very effective use of this philosophy in their science teaching, often starting their lessons with a question, asking students what they already know, and then helping them to plan how they could find out more. In one lesson, introducing the solar system, students worked in groups to write down what they already knew and also what they would like to find out. The teacher used this information to help them plan some simple research, making appropriate use of the textbooks, and also to identify some of their ideas that were misconceptions needing further study later.

Many teachers appreciate the value of practical work, often using demonstrations to make learning more effective; for example, generating a gas by reacting vinegar with baking soda to illustrate a chemical change. Students responded very well to these useful and exciting demonstrations and teachers were often able to help the students to observe carefully what was happening and to link it into their wider science understanding. For example, in one lesson where this demonstration took place, a student asked what the gas was. On being told it was carbon dioxide, she replied “Oh, that’s a bad gas for us”. Another student commented “but its good for plants” and a very useful discussion followed, steered by the teacher and involving almost all the class.

Students themselves are involved in practical work in some lessons and many teachers appreciate that these practical activities call on skills that are different from those needed in other subjects. As a result, some students are able to perform better in these activities than in other parts of the curriculum. This applies particularly to boys and is an important way of keeping them interested and successful in education.

In a few lessons, these useful practical activities are extended into genuine investigative work; in which students plan and carry out experiments to find the answer to a question that matters to them. These investigations are important because they show students how science works, emphasising the importance of raising hypotheses, fair testing, accurate observation and honest reporting. The increased importance of investigative work, as apposed to demonstrations and illustrative practicals, is a relatively recent development in science education. Many teachers will not have had experience of investigations in their own science education and have had little opportunity, through professional development, to build up an understanding of the purpose of investigations or how to manage them in class. Consequently, investigations are not taught well in many classes. In discussing the idea of an investigation, some teachers refer to a hypothesis as a guess. In contrast, in a class that had looked at the way coloured water rises up a celery stalk and were discussing how they could investigate what factors effected the speed at which the water rises, a student suggested that higher temperature would lead to a greater speed. Encouraged by the teacher, she justified her hypothesis because that was what happens in diffusion, which they had looked at earlier in the year, and the processes might be similar. This thoughtful use of learning from a different branch of science is far from a guess.

Many primary teachers make very effective use of the good relationships they have with their students to encourage discussion, often posing questions that make them think, responding positively to their answers so that feel confident in replying and using humour to encourage them. This pedagogy is very effective in science teaching; helping to develop understanding and enthusiasm for the subject. Sometimes its effectiveness is reduced by teachers’ own limited understanding of science, so that opportunities to extend understanding are missed and misconceptions are perpetuated.

Curriculum

Generally, as required by the Department of education Services, primary schools have two hours per week allocated to science for each class. This is an appropriate allocation of time for students in this age range and for the material to be covered. Some schools are using this time more flexibly, realising that science is a useful context to develop other skills, such as literacy.

The science curriculum is currently defined for schools by the Department's curriculum document for science. As far as it goes, this is a suitable document, comparable in scope and coverage to the curriculum documents produced in other jurisdictions, such as New Zealand and the United Kingdom. In all cases, curriculum documents need further work to translate the outline that they provide into sequences of learning activities for students, often called programmes of study. These programmes establish the approach that teachers should take and also the depth to which the topic is to be studied. Schools have been given some support in this process with an outline of which elements of the curriculum to cover each year. This outline is closely linked to sections of the textbook which is provided for each school, together with kits of equipment for practical activities.

This way of supporting schools has not resulted in an agreed or common approach to science teaching in Cayman, or even within individual schools. There is considerable variation in the depth to which topics are studied and, more significantly, in the balance between learning facts and engaging in the process of science. Whilst being a useful resource, the text books are part of the problem. They provide much more detail than is necessary and give much more emphasis to facts than to inquiry.

Planning for science in schools is generally left to individual teachers or to year groups; there is little planning that runs across a whole key stage. Following the guidance and over-using the textbooks results in classes meeting similar topics in the same order each year. Biological topics come first in the text books and physical science ones come later. Classes who spend too long on biological topics do not reach the later topics. This can happen year after year, so that students study an unbalanced selection of science topics.

The new national curriculum for science provides an opportunity to address these problems of interpretation by helping schools to establish a clear understanding of the depth of coverage that is appropriate and the approach that is needed for students to learn science well.

Leadership and management

Nationally, the drive for improvement in schools has focused on literacy. Resources have been allocated to support this area of the curriculum and other areas, including science, have a lower profile. Understandably, principals in schools have not seen science as a priority, particularly when they have been able to overlook the low performance of students in the key stage tests as described above.

Most schools have a teacher who is designated as the science coordinator. The role of coordinator has not been clearly defined, either through effective written job descriptions or in practice. Many of them provide what support they can for colleagues, including suggesting ideas for lessons, and are keen to develop their role further. They rarely have time allocated to support planning across the school or to visit other classes. There has been no professional

development to help teachers in the role of science coordinator and there is no network for science coordinators to join in order to share ideas and support each other.

In contrast to the developments in literacy, schools have very little input from science specialists. There are very few links with science departments in the secondary schools and they have not made use of professional organisations, such as the National Science Teachers Association or the Association for Science Education, which have sections devoted to science teaching at primary level.

Overall, there has been a lack of national leadership in the development of science and improvements have taken place through the initiative of individual teachers and schools.

Accommodation and resources

There is little specialist provision for science in primary schools. Most science takes place in the classrooms and, in most cases, this is adequate; although some classrooms are too small, notably for older students at John A Cumber Primary School.

Some schools make good use of field work to bring the subject alive. All schools value the annual study of the mangrove ecology that is provided in conjunction with the National Trust. A number of schools have their own contacts which they use, for example, to visit the waste disposal facility to study recycling. Like much of the science in primary schools, these field trips tend to have a bias towards biological topics. It would be useful to consider developing a list of field work opportunities available to schools and ensure that it contains visits to support themes of local importance and relevance, such as the use of energy and water on the island.

Preparations for the new national curriculum

Schools welcome the new curriculum for science and many are already planning how to bring it into use in September. They support the inclusion of design and technology in the document. Many schools already include technology work as part of their science lessons, for example, making measuring instruments as part of their work on weather, and they see the new curriculum as a natural extension of this approach.

Schools see the benefit of assessing students by using performance criteria and awarding increasing levels of attainment as they gain mastery of a subject. They recognise that teachers will need support in applying the new levels to judge the standard of students' work and that parents will need to be helped to see the value of the new system as opposed to the percentage mark that they are used to receiving to describe their children's performance.

Preparations for the new curriculum are leading to some productive collaboration between schools, such as the networking of the Eastern District schools with Creek and Spot Bay Primary School in preparation for their introduction of the International Baccalaureate.

Plans to improve teaching and learning, which are part of the programme for the introduction of the national curriculum, will have some positive impact on science provision, particularly where they encourage effective discussion, questioning and involvement in practical work. However, there are elements of pedagogy that are specific to science teaching, such as managing the design and conduct of investigations. Also, teachers need to have sufficiently high levels of

skills and understanding of science in order to avoid passing on misconceptions to their students and to make full use of opportunities for extending comprehension that arise from questions and discussion. A purely generic programme to improve teaching and learning may not address these issues; so, specific support should be provided for teaching and coordinating science in the primary schools.

Aspects of effective provision – case studies

At George Town Primary School the principal has recognised that students are not performing as well in science as they are doing in other subjects. Although she considers that the key stage tests are too hard, she recognises that they point to students not being able to tackle investigations well enough and to knowing more about biology than the physical sciences. As a result of her effective monitoring of the work in her school, she knows that this is because of the way the students have been taught. To address this issue, she has appointed as science coordinator a teacher whose work is respected by her colleagues and whom she knows has the right approach to science. Although the coordinator has no additional time for her work, she is able to influence other teachers by helping them to plan their lessons; by suggesting interesting approaches and by providing a model of effective pedagogy through her own teaching.

In a lesson that she taught as an introduction to the solar system, she made the order of the planets and their motion around the sun come alive to the students by taking them outside and getting them to dance along an orbit for each planet's year while spinning round to create day and night. Everyone was thoroughly involved, either as a planet, a moon, an asteroid or a comet zooming in from outside. It was the sort of lesson that inspires students to find out more. If other teachers saw it, they would take many of the ideas and approaches into their own classrooms.

At North Side Primary School the principal has recognised that performance in science needs to be raised. The school has introduced an assessment system for English and mathematics that measures a student's performance as above, below or at the level expected for that age. This is being introduced into science, and teachers are collecting examples of students' work that is typical of each level of achievement. Assembling this portfolio will be a very useful process in helping teachers to judge levels of performance and to decide what a student needs to do to improve. Also, the work in the portfolio will be valuable reference material to help the school move easily into using the criteria referenced levels of the new national curriculum.

At Savannah Primary School the science coordinator and principal have examined their students' performance in the key stage tests and realised that the test is measuring skills and understanding that are different from those that the text books are supporting. To address this mismatch, they have looked closely at the questions that are asked in the tests and have begun to adapt the way that science is taught at Savannah. Teachers are placing more emphasis on practical work and investigations, and they are looking at planning from year to year in order to ensure that students meet a good range of science topics and make progress.

At the Lighthouse School, science is often closely linked to the students' development of life skills. As part of the overall philosophy of the school, the principal and teachers are determined that their students will make as much progress as possible. The principal summed up their approach when she said, "Our students really want to learn. We've just got to find a way to make it happen". As a result, lessons are lively and carefully matched to the needs of individuals and the group. In a lesson on the differences between living and non-living things,

students danced and sang about growing, breathing, eating and moving before moving on to look at the tank of fish that the teacher had brought in. They considered how the fish breathed and moved compared with humans and were delighted to see the gills and fins working. They were even more thrilled to see the hamster that appeared next. The teacher skilfully linked the discussion that followed with how we need to look after ourselves through diet and exercise. Throughout the lesson, the students were encouraged very successfully to work together and to treat the animals with care and respect.

Appendix 1

International perspective

Within the Cayman Islands, the recent review of the national curriculum has developed the concept of the "Educated Caymanian," and highlighted the role of science and design and technology in contributing to the achievement of this aim. The document, concurring with the sentiment of most countries, emphasizes that science is a fundamental area of a primary school curriculum.

The recent conference of CARICOM representatives meeting in Jamaica in 2007 emphasised the importance of science as part of the primary curriculum, both for the thinking skills that it helped students to develop and, also, to lay the foundation for skills that are needed in the economy of the region.

Science is part of the compulsory curriculum in the twenty countries recently surveyed by the International Review of Curriculum and Assessment Frameworks (*INCA*) project, (*International trends in Primary Education*), and most of these countries prescribe time allocations for its study. The survey also indicated a trend towards centrally produced guidance in the form of schemes of work, lesson plans and examples of students' work. Although there was no single prescribed teaching style, there was an emphasis on group work and independent learning. In addition, the survey showed a trend towards external assessment to help teachers identify how well students are doing, to plan work and to establish accountability. These trends are reflected in the Cayman Islands' new national curriculum.

Appendix 2

Schools visited

Lessons were observed in the following schools:

East End Primary School, North Side Primary School, Savannah Primary School, Red Bay Primary School, George Town Primary School, Prospect Primary School, John A. Cumber Primary School, Creek and Spot bay Primary School and the Lighthouse School.

Discussions were held with staff at all of the above schools and Bodden Town Primary School and West End Primary School.

Summary of grades in lessons observed:

Key Stage	Grade	percent at each grade			
		Teaching	Learning	Standards	Lesson
all	1	3	3	0	3
	2	40	40	7	40
	3	37	33	60	33
	4	20	23	33	23
KS2	1	7	7	0	7
	2	40	40	7	40
	3	33	33	67	33
	4	20	20	27	20
KS1	1	0	0	0	0
	2	40	40	7	40
	3	40	33	53	33
	4	20	27	40	27