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The Introduction of the New Curriculum and Senior High School System in the Philippines : report of the consultation exercise undertaken in November 2015

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The Introduction of the New Curriculum and Senior High School System in the Philippines

Report of the Consultation Exercise undertaken in November 2015

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Executive Summary

Studies conducted across the globe have identified innovation and education in the fields of Science, Technology, Education and Mathematics (STEM) as critical determinants economic prosperity. Indeed, STEM educated and trained individuals have been shown to be major determinants of innovation and, thus, contributors to significant economic productivity. Capitalising on such reports, countries such as China and India have developed key policy strategies aimed at increasing the number of scientists and engineers in an attempt to reap the benefits of a STEM-educated workforce.

Also, SEAMEO member countries are currently investigating proposals for a common curriculum and educational standards. The SEAMEO Basic Education Standards initiative is aiming to develop a common curriculum framework which reflects those of world class performing countries identified through international assessment tests such as PISA. The focus is science, mathematics, English and entrepreneurship at secondary schooling level and will be anchored by ASEAN values and culture. There is a clear commitment to STEM education in the region and the reported Philippine initiative is well placed to provide the necessary STEM education experiences for students that will lead to an increase in participation in STEM study and careers.

In the Philippines, the education system has initiated an increase from ten years to twelve years of study and introduced a new science curriculum to enhance the teaching and learning of science and science related subjects. The Sheffield Institute of Education, Sheffield Hallam University was asked by the CHED K to 12 team to conduct a consultation on aspects of the move to the K to 12 curriculum and the introduction of the Senior High Schools initiative.

Two senior researchers from SIoE (S. Bevins, G. Price) visited Manila in November 2015 and worked directly with the CHED team, invited teachers and HEI academics through informal discussions and workshops to gain an understanding of the K-12 and SHS initiative.

The SIoE team developed a series of tools to aid reflection and analysis of the science curriculum. These are included in this report in the appendices.

This White Paper will present findings from the consultation process based on the evidence gathered. It also sets out a list of recommendations aimed to support effective development and progress of the initiative. These recommendations emerge from the consultancy process.

1: Recommendations

The new Science curriculum

1 Develop and implement a rigorous evaluation strategy for the new curriculum and Teacher Guide initiative to guide ongoing development.

We strongly recommend that the partners consider developing a rigorous evaluation strategy that will provide objective data to document and guide development of the initiative.

2 Develop clearly defined success criteria for the project to codify progress.

It is difficult to find evidence of clearly defined success criteria for the initiative. This makes it difficult for the collaborative group (DepED, CHED and TESDA) to assess the effectiveness of approaches such as the Teacher Guides. Thus, it is recommended that the partners develop success criteria which clearly define the key aims of the initiative and show how achievements will be identified.

3 Formulate a clear, public strategy for addressing issues arising to increase chances of success and to build confidence amongst stakeholders.

There appears to be an absence of a clear medium to long-term strategy for maintaining the initiative. This should be addressed through the development of a plan that builds on data from an evaluation and clearly shows the way forward with details of how that will be achieved including key milestones, objectives and deliverables.

4 Develop a curriculum commentary for teachers to clarify what is included in the curriculum, and what is not necessary, to avoid 'content creep'.

Teachers who are unfamiliar with the boundaries of the knowledge and skills required by a new curriculum tend to over-estimate the material they need to cover - particularly in the content domain. This makes a difficult task even more demanding. By developing a curriculum commentary it is possible to reduce this elaboration and provides an opportunity to emphasise the key concepts and skills that are needed to be a successful student.

5 Identify and clarify the Higher Order Thinking Skills required by the curriculum to ensure teachers are clearly focussed on the important issues and not merely covering more and more content.

The curriculum document as it stands appears to value content over skills. This is further emphasised in some of the Teacher Guides, which will be seen by many teachers as official documents. There is the potential that these will reinforce a view of the curriculum that has an unbalanced emphasis on content coverage over than competency-building.

Teacher Guides

6 Improve the support for Teacher Guide writers.

Consideration should be be given to the development of a collaborative group consisting of school teachers and academic writers who could help to clarify existing suggestions to Teacher Guide writers over issues such as expected length of lessons, level of background science support, sequence of teaching and learning activities etc.

7 Develop a national textbook to support science teachers

A number of the Teacher Guides included detailed background notes for the teachers which made them ungainly and difficult to use in the classroom. We recommend that CHED or DepEd consider driving the production of a national textbook which could provide this background science knowledge and so relieve the burden on teachers and curriculum developers.

8 Make better use of the insights gathered from teachers in the CHED consultation to ensure the Teacher Guides are appropriate for teachers in schools.

At the moment the Teacher Guides reflect the interests of the writers (i.e. HEI professionals) over the needs of the SHS teachers. The insights from the teachers gathered during the consultation are valuable and should be used to drive Teacher Guide development. A consultation group with strong teacher representation should be established to guide further Teacher Guide development. This group should take a strategic, forward-looking role unlike the delivery role of the group mentioned in recommendation 6. Despite this difference in focus there should be some common membership of the two groups to ensure 'joined up thinking'.

9 Commit to ongoing evaluation and development of Teacher Guides to improve their quality and to build confidence amongst the teaching profession that their voice is being heard in the program.

A clear, public statement to stakeholders that the Teacher Guides as they stand are the first edition and that they will be modified in the light of experience will build confidence and commitment from teachers.

Professional Development for Science Teachers

10 Develop further, ongoing support for teacher development to ensure sustainability.

It is clear that the participating teachers value Professional Development opportunities but they feel that the current proposals are inadequate. We suggest that the partners conduct a Teacher Development Needs Audit and then put in to place a structured approach to Continuing Professional Development (CPD) activity.

Classroom practice

11 Ensure alignment of examination system with curriculum aims and objectives

Considerable evidence from around the world suggests that teacher practice is often driven more powerfully by the assessment systems than the curriculum documents those systems are supposed to support. There is a danger that, with the pressure to pass examinations to enter prestigious schools, the teachers will simply end up 'teaching to the test'. DepED should review the current public examination system to ensure that it is fit for purpose and rewards the knowledge, skills and attitudes the new curriculum claims to promote. It should also explore a range of examination and assessment techniques to ensure that they are testing the skills and knowledge that the curriculum writers identify as valuable.

2. Introduction and context

2.1 The background

Through the Republic Act 10533 and the Enhanced Basic Education Act of 2013 the Philippines committed to introduce a new K-12 school curriculum, involving raising the school leaving age by two years, and to introduce a new science curriculum to enhance teaching and learning. These reforms are being led by the Department of Education (DepEd), the Commission on Higher Education (CHED), and the Technical Education Skills and Development Authority (TESDA). The additional two years will see the introduction of Senior High Schools (SHS) which will engage learners at grades 11 (starting 2016) and 12 (starting 2017).

2.2 Supporting Teachers

CHED, in partnership with the Philippine Normal University (PNU), is developing 21 Teacher Guides (TG) for SHS Grades 11 and 12 in STEM subjects. The TG aim to support the classroom practice of SHS teachers through activities and approaches which target the new curriculum. They typically contain instructions to the teacher about how to run the lesson, background science knowledge, answers to questions and, in the best cases, advice on any potential problems. They generally follow a standard sequence: Introduction, Motivation, Instruction/Delivery, Practice, Enrichment and Evaluation.

Six writers from Higher Education (HE) institutions have been engaged in each subject area. January 2016 has been identified as the target date for the initial TG to be published and distributed to all SHS science teachers in cooperation with DepEd. In addition, CHED and PNU aim to provide professional development for SHS teachers nationally which will be delivered by private institutions. The underpinning aim of this approach to teachers' professional development is to highlight the potential of SHS in preparing learners to pursue higher education and, eventually, careers in science and technology.

2.3 Greater Scientific Literacy

A major concern, identified from consultations with educators (high school and college), revolves around the new science curriculum's focus on content knowledge and facts to the detriment of scientific literacy. With a belief that developing young people's attitudes about, skills in, and knowledge of, STEM is critical for economic growth and prosperity, CHED, DepEd and TESDA state that science needs to be conceptualised not merely as a subject but as a lens of understanding the world and a method of knowing and inquiry.

The introduction of the new SHS intends to increase the number of students that will pursue college courses in STEM. However, with unique characteristics such as superstitions, pseudo science and religious culture, a lack of essential equipment and large class sizes to mention a few, the intended changes are extremely ambitious and possibly unprecedented in a global context.

This White Paper will detail the findings from a consultation process, led by senior researchers from Sheffield Hallam University, and will provide support for the development and implementation of the Teacher Guides as well as wider guidance and recommendations.

3. Methods

Two senior researchers from the Sheffield Institute of Education, Sheffield Hallam University undertook the consultation. The framework for the consultation consisted of four key methods shown in table 1.

Table 1. Consultation Framework

Method	Data Source and Purpose
Document analysis	Key documents were analysed to establish a clear understanding of: • key aims and philosophies • strategies • curriculum content and competencies • existing Philippine education system
Stakeholder discussions	Initial information gathering to establish an understanding of: • key aims and philosophies • strategies • existing and perceived barriers • key participants • desired outcomes
Review of Teacher Guides	Review workshops were conducted to provide intelligence for draft Teacher Guides and support further development. The Lesson Focus Analysis tool was employed to support the reviews and help gather data.
White Paper	A White Paper was published to disseminate findings and recommendations.

Document analysis

Document analysis is a systematic procedure for reviewing or evaluating documents. As with other analytical methods in qualitative research, document analysis requires that data be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge. This method was used to enable a thorough understanding of the new science curriculum and aims of the SHS system. Key documents such as the new science curriculum, science syllabus (K to 12), and published literature were analysed to inform thinking about performance standards, content, and learning competencies.

Stakeholder discussions

Stakeholder discussions were conducted with members of CHED, HE academics and STEM teachers. A total of twenty-six stakeholders (university academics, CHED staff and STEM teachers) participated in the discussions which took place over three days.

SIoE researchers employed an interview protocol (Appendix 1) to guide discussions through a design meant to encourage flexibility and not to restrict a flowing conversation. The protocol contained questions which were identified as crucial to developing a critical insight into stakeholder thinking, concerns and views.

Seven STEM teachers were also engaged through Nominal Group Technique (NGT). This approach is a useful way of establishing a consensus and is an effective way of prioritising issues. The teachers were asked to think about their classroom practice and then asked to identify an issue which they felt significantly impacted on this. They each wrote down their issues (without any discussion). As a group then they shared their individual thoughts and after some discussion a new and agreed list of issues was identified. The result was a consensus answer which revealed key concerns and potential of the initiative.

Table 2 summarises the output of the NGT session. The further to the right in the table the stronger the feelings elicited in the sense that these have been agreed by both teachers in each pair. It can be seen that there is a degree of concern amongst the teachers about the curriculum, the facilities and even the students. DepED and CHED clearly have a task to do in terms of building confidence for the significant move forward involved in the new curriculum and school extension.

Table 2. Nominal Groups Technique results

Issues identified by individuals	Consensus issue agreed by each pair
• Are the teachers ready? • Are the students ready?	• Are we ready to change curriculum, facilities, students?
• Is the curriculum right? • How can schools keep their students?	• Are the buildings and facilities fit for purpose?
• Do we have enough equipment? • How will Science high School change and develop?	• Student communication skills need to be developed.

Following this activity a SWOT analysis was undertaken to further explore teachers' perceptions. All words are the teachers' not interpretations or summaries by the researchers.

Table 3. SWOT analysis

Strengths	**Weaknesses**
• Highly qualified teachers. • Good students (motivated, aspirational) • Support for development. • Supportive and involved parents	• Funding - the day to day running and special events. • Cost charged to students. • Facilities and equipment are low.
Opportunities	**Threats**
• For growth (supported) • Trying and support for change. • Competitions and rewards • Funding growth • More staff	• Critical parents • Politics (funding) • Difficult to plan without knowledge of funding. • Students dropping out (schools becoming smaller). • Staff leaving for better jobs.

The session continued by asking teachers to think about 'the perfect STEM student'. This involved them identifying the key knowledge, skills and attitudes a good STEM student would have. They worked in three groups to develop these. Table 4 shows their results. Again, all words are the teachers' not interpretations or summaries by the researchers.

Table 4. The perfect STEM student

	Group 1	Group 2	Group 3
Knowledge	• Understand the basic / fundamental concepts of science. • Apply science concepts necessary for environmental protection. • Relate science concepts to everyday situations. • Understand the role played by science in societal / community development.	• Basic concepts: can relate them to real life / current events. • Interrelationships: across different disciplines. • Scientific method: as a way of thinking.	• Good grasp of scientific concepts. • Distinguishes between scientific facts and common beliefs (superstitions). • Provides evidence / proofs for any claims. • Knows current trends in technology. • Energy is neither created not destroyed. • Cell is the basic unit of life. • The whole is greater than the sum of the individual parts. • Basic cures to non-threatening diseases.
Skills	• Use scientific method to solve problems. • Do scientific research that applies science process skills. • Demonstrate critical and logical thinking skills in dealing with scientific problems. • Apply scientific and technological skills in developing innovations.	• Science process skills: including laboratory skills. • Critical thinking. • Communicates well: written and oral. • Maximises use of technology. • Cites references: can distinguish between reliable and questionable sources. • Resourceful. • Collaborative.	• Applies the scientific method to answer / solve everyday problems. • Can easily differentiate things (even with slight variations) • Can collect data relevant / pertinent to the problem. • Can provide answers and explanations to others with queries in science. • Can innovate existing products.
Attitudes	• Love for learning. • Perseverance. • Scientific honesty. • Open-mindedness. • Critical thinking.	• Curious. • Patient. • Passionate / dedicated. • Risk-taker. • Delays judgment. • Resilient. • Responsible.	• Organised. • Logical. • Result-orientated. • Curious. • Skeptical (in a good way) • Does not get easily frustrated by failure. • Observant. • Open-minded: willing to accept suggestions. • Can easily adjust , cope with uncertainty.

Teacher Guide reviews

Collaborative workshops were held with the Teacher Guide writers to (a) gain an understanding of their approach and thinking and (b) to provide critical feedback to progress development of first draft material. A total of fourteen HE academics/writers participated in the workshops.

The researchers designed and implemented the Lesson Focus Analysis tool (appendix 4) to enable a rigorous review of the Teacher Guides and to provide writers with a sustainable tool to use for future developments. Detailed reviews of each Teacher Guide can be found in appendix 3.

A White Paper

A White paper has been published to document and disseminate findings of the review of Teacher Guides and other aspects of the consultation. Recommendations are also offered in an attempt to support progress and development of the initiative.

4. Findings and commentary

4.1 Structure of the findings

These themes structure the findings section of the White Paper and will form the basis of recommendations to CHED and interested parties. Findings have been informed by analysis of data collected through the consultation framework and our understanding of curriculum developments across the world.

- The new science curriculum
- Teacher Guides
- Professional Development for science teachers
- Classroom practice
- Students

4.2 The new science curriculum

The K-12 science curriculum describes the attitudes, skills, knowledge and understanding that all pupils should develop. The SIoE team developed a number of tools (Curriculum Assessment Task: Science and Curriculum Trends) to analyse the curriculum and these are included in the appendices. It is envisaged that Philippine educators will be better placed to use these tools, given their local knowledge and greater exposure to the Philippines curriculum, than the SIoE team.

Tool	
CAT:Sci	CAT:Sci gives a broad brush view of a curriculum across four dimensions: • **cultural relevance** - is the material suitable for the life experiences of the teachers and students? • **conceptual coherence** - are ideas developed in a sensible and supportive manner over a number of lessons, terms, years? • **sufficiency of coverage** - is there enough knowledge and understanding (content) to equip students for their work yet not so much that they are overwhelmed in unnecessary detail? • **sophistication of skills** - are the skills developed sufficiently conceptually demanding or are they simply manipulation / mechanical?
Curriculum Trends	This tool plots the relative positions of key concepts in a science curriculum and compares this with curricula from other countries.

However, a number of points are worth mentioning at this stage. The curriculum claims in the conceptual framework to ‘be learner-centred and inquiry-based’ (line 17). The teachers, and the writers of the Teacher Guides, felt that there was little time for inquiry as the curriculum contained far too much content. In the NGT discussions, their worries about implementation included a specific, overt reference to the excessive content demands the curriculum makes. This was reinforced during discussions of the curricula proposed for the SHS and became a recurrent theme during analysis of the Teacher Guides. The existence of the Teacher Guides, in themselves, further suggests that the curriculum contains a lot of material (particularly at SHS level) that will be unfamiliar to the teachers.

4.3 Teacher Guides

A selection of Teacher Guides were supplied prior to the visit and were reviewed before meeting the relevant authors. Further Teacher Guides were supplied when the SIoE team arrived in Manila and these were reviewed live with the writers.

Each Teacher Guide was read through in its entirety to gain a sense of its purpose and style. It was then analysed in more detail using the Lesson Focus Analysis (LFA) Tool (see appendix 5) to aid reflection and identify issues generated by the key purpose of the lesson. This key purpose was described in terms of the concept students would be expected to master by the end of the lesson. It is expressed in this form rather than a list of content because concepts are more powerful than simple facts. For example, if students can understand 'how *x* is related to *y'* (a basic causal link) then they can use this concept predictively in novel situations whereas merely knowing a selection of facts is less useful. The remainder of the LFA form explored how the lesson supported, or obscured, the development of this central concept.

The reflections from these procedures were shared with the writers through informal collaborative discussion sessions. Contributions were invited from the writers both as a way to check that the SIoE researchers had understood the Teacher Guides and to help the writers to develop their own skills in using the LFA.

There was very little disagreement about the comments and when the writers were invited to conduct their own analysis the insights were almost identical to SIoE ones. All writers agreed that the LFA tool was useful and productive tool.

General comments and suggestions concerning the Teacher Guides are given below with details about specific Teacher Guides given in Appendix 6.

- The lesson plans ranged in size from one hour to four hours. It would be better to agree a standard lesson time and then convert some of the longer plans into a series of lessons. CHED could offer guidance on this. The time allowance should reflect Senior High School (SHS) lesson durations not university lecture timings.
- Including summaries of the lesson plans in each guide helps teachers see the overall shape of the lesson at a glance (see the physics Teacher Guides for a model).
- The many references to support resources (online and offline) are useful but a number of these resources appear to be set at university level. These could lead to 'content creep' whereby the amount of content or the level of treatment increases beyond that intended by the curriculum for SHS. It is important to ensure that the support materials are clearly identified as for students or to provide background knowledge and understanding for teachers.
- There is a significant variation in demand and accessibility across the Teacher Guides. This probably reflects the reality of the curriculum document but does mean that some lessons are approachable and relatively easy (sedimentation in History of the Earth) while others are difficult, obscure and entirely mathematical (Gauss' Law). Time should be devoted to clarifying difficult topics and making them more

accessible - perhaps by testing a variety of approaches and selecting the ones that seem most effective.

- The lesson plans often look like chapters from a book or an essay in that they start with a series of general statements, often expressed mathematically, and then move on to particular examples. This is entirely suitable for a high-level textbook where the author has *already mastered* the material and is seeking to display it effectively for the reader. However, existing research on teaching and learning suggests that the opposite route is more appropriate for students to *gain* understanding. Since the Teacher Guides are meant to structure learning for students rather than experts it would be wise to start with familiar, simple, concrete and specific examples and then move towards more exotic, complex, abstract and general principles once the specific examples have been understood. Many of the lesson plans would benefit from this reversal in sequence.

- The best lesson plans provided detailed instructions directly to the teacher. These instructions are very useful, particularly when backed up with suggestions for time required and notes about potential problems and how to solve them.

- Some of the guides included a great deal of background information, in effect they were attempting to provide a textbook for the teacher. This made the lesson plans very long and cumbersome and difficult to manage in a busy class. It would be better to move this extra support into a separate document and ensure that the lesson plan focuses on instructions of direct relevance to the particular lesson.

4.4 Professional Development for science teachers

CHED have planned for a series of national development events to take place early in 2016 to support the rollout of first generation Teacher Guides and the participating teachers at the workshop welcomed this initiative strongly. They also stated that they would value professional development opportunities on a more regular basis. They identified subject content and pedagogical approaches as key areas of focus for professional development activity.

TESDA are developing Learning Action Cells (LAC) which are groups of teachers who engage in reflective practice and share insights and learning. Data from the stakeholder discussion groups indicate that developing a community of teachers is viewed as highly important by CHED, TESDA and DepEd but also the participating teachers. Teacher buy-in to the initiative is recognised as critical and the establishment of the LAC concept is an effective way forward. Data from the stakeholder discussions also show that teacher Action Research emerged as a potential approach to developing the LACs further, although it was acknowledged that participating teachers would need support to develop their knowledge and understanding of Action Research to engage effectively with the approach.

Appendix 7 provides a summary of the characteristics of successful science teachers based on work in SIoE, the UK and Australia. When preparing CPD for teachers the framework could act as a reference to check potential programmes against.

4.5 Classroom practice

Seven STEM teachers from five schools participated in a stakeholder discussion on the second day of the consultation. Analysis of data from the NGT and SWOT activities indicates that the teachers are concerned with two critical issues:

- Readiness of science teachers
- Facilities and equipment

The teachers stated that they have concerns over their 'readiness' (expressed in terms of content knowledge, pedagogical skills and laboratory support) to deliver the new science curriculum content and engage with the Teachers Guides. They believe that the curriculum is over-laden with content and leaves little room for innovative approaches to teaching. They also feel that they need more time and support to fully integrate the TG into their classroom practice.

They also demonstrated concern about what they view as a lack of quality facilities and equipment. The participating teachers suggested that many schools do not have adequate classroom and/or laboratory facilities and that a lack of scientific equipment is commonplace. They stated that teaching the key competencies identified within the curriculum requires correct facilities and equipment and that many teachers will not be able to provide full coverage of curriculum content with poor facilities and equipment. In addition to this, many schools suffer from extremely large class sizes (ranging from 40 to over 80 students) which compounds the difficulty of effective teaching and learning greatly.

These two critical concerns link with issues raised in section 4.4 regarding teacher Professional Development. The teachers demonstrated their keenness to engage in Continuing Professional Development activity (CPD) that would support their classroom teaching and, in particular, delivery of the new curriculum.

While not strictly part of this project, the insights from CHED's consultation with teachers are worth mentioning. They are described in the presentation offered to SIoE on the first day of the project and seem a useful source of information about the implementation of the new curriculum. The text is available elsewhere.

Many of the insights and suggested actions were reflected in the teachers' descriptions of a 'perfect STEM student' (see p 9). There is a willingness and a desire on the part of teachers to help students to:

- Develop Higher Order Thinking Skills.
- Focus their understanding on the key issues of science rather than collecting large amounts of facts: going 'deep' rather than 'wide'.
- Act as researchers and inventors rather than simply consumers of science content.
- Improve their communication skills.
- Apply their scientific and technological knowledge and understanding to societal problems.

All of these are in harmony with many of the curricula of high performing countries in S. E. Asia and around the world. This shows that teachers, even while they are concerned about many of the implementation issues surrounding the science curriculum and the SHS initiative are potentially a major asset for the Philippines. It is important that CHED and DepEd support them appropriately.

4.6 Students

The teachers also expressed concern over the readiness of their students. Clear anxiety was expressed by the teachers when they discussed the issue of student retention. They suggested that only 50% of students stay on beyond 11 years-of-age and that if the curriculum makes too many demands this figure could increase. However, the teachers accepted that this point could be somewhat off-set by the main purpose of the curriculum which is to develop student competencies to increase their college readiness and employability. The teachers felt that if the students recognise this and can engage effectively in STEM education the retention rate may improve.

The teachers again highlighted the detrimental impact of large class sizes by suggesting that a majority of students have poor communication skills and that there is a need to focus on addressing this issue. However, they felt that this was unlikely given the frequency of large class sizes and therefore, little opportunity for teachers to work with small groups or individual students.

SWOT analysis shows that parental support for students learning is strong, although some parents are often critical of their children's learning particularly regarding examination preparation which they perceive as being less than adequate. Overall though, the data shows that schools do facilitate a good community spirit by involving parents which in turn has a positive impact on their motivation to learn.

5 Conclusions

It is clear that this initiative is brave and potentially wide-reaching. If successful it could significantly change student experiences of STEM education in a very positive way. However, much needs to be addressed before any successful outcomes can be expected. Data gathered through a range of approaches show that there are critical elements which need attention and this report sets out a series of recommendations which the authors feel are necessary to enable successful progression of the initiative and long-term impact.

In order to drive this initiative forward all partners will need to liaise consistently and offer support to each partner in order to progress collaboratively. The evidence gained through the reported consultancy period indicates that this has already begun and is likely to continue.

We would also like to add our belief that, if these recommendations are followed and teachers are courageously led and effectively supported through the coming changes, the Philippine education system is about to enter an era of exciting and productive development.

Finally, it is worth stating that the commitment of the Manila team demonstrated throughout the consultancy period inspires confidence for the future development of this initiative.

Appendix 1: Interview Protocol

The following interview protocol was designed to act as a prompt rather than a rigid interview schedule in order to maintain flexibility during discussions so as not to restrict the conversational flow. The protocol was not designed to be exhaustive but merely a prompt tool containing key themes/issues to be discussed.

Curriculum

What was the motivation for a new science/STEM curriculum? What was the main purpose?

What is the density of the curriculum and how does it differ from previous curricula?

Schools/Teachers

Describe the system of Initial Teacher Education (ITE) in the Philippines? What are the key features?

Do teachers engage in CPD? How often and how is this delivered/organised?

What are the communication mechanisms between the partners and schools? Are these effective?

What assessments model(s) are in place?

Students

What is the main classroom delivery mechanism? What is an average class size?

Are students, in general, motivated? What are the key issues in the Philippines regarding students' science education?

What resources are available to support student's learning?

Partners

How are the partners working together? What specific areas do each own?

Appendix 2: Curriculum Assessment Tool: Science (CAT:Sci)

When and why to use this tool

CATSci gives a broad brush view of a curriculum plotted across four dimensions:

- **cultural relevance** - is the material suitable for the life experiences of the teachers and students?
- **conceptual coherence** - are ideas developed in a sensible and supportive manner over a number of lessons, terms, years?
- **sufficiency of coverage** - is there enough knowledge and understanding (content) to equip students for their work yet not so much that they are overwhelmed in unnecessary detail?
- **sophistication of skills** - are the skills developed sufficiently conceptually demanding or are they simply manipulation / mechanical?

How to use this tool

1 Identify a section of the curriculum you wish to analyse. This can be a Year (e.g. Year 7), a topic (e.g. photosynthesis or chemical bonding) or a discipline (e.g. physics, Earth science) or a selection of items chosen to provide a stratified sample (e.g. the second item on every page in the curriculum document).

2 Looking at the individual components you have identified assign each one into the correct box in the tables that follow. This will involve making judgements and two assessors might want to work independently at first and come to a shared decision after reviewing their assessments.

Cultural relevance			
Criteria	• Material is not relevant to, or respectful of, local culture and experiences. • It looks like it has been simply copied from elsewhere.	• Material is culturally neutral. It appears stripped of local flavour and presents as a global solution.	• Material recognises and celebrates local circumstances, expectations and culture. • Topics are clearly linked to local experiences.
Exemplars	Use of northern hemisphere plants and animals in an Australian ecology curriculum.	Curriculum described in purely ‘scientific’ terms, e.g. description of a topic on transition metals that does not specify any particular examples in a country that is the world’s leading exporter of copper.	Development of much of the plant biology through a curriculum around orchids in Thailand - a major exporter of orchids.

Conceptual coherence			
Criteria	• Topics are heavily weighted towards memorisation of facts with little reference to underlying, unifying themes or ideas. • Topics are repeated random or developed without proper underpinning knowledge being in place.	• Some progression of development is visible within subjects and within years. Some attempt to link ideas across years although this can be in terms of titles rather than underlying ideas. • No connection between different disciplines.	• Clear progression of development is visible over terms. years and the whole school experience. • Different areas of the curriculum collaborate to ensure they support each other. • Students are encouraged to make links with previous work through unifying ideas.
Exemplars	Electrical symbols, circuit diagrams and calculations using Ohm's Law are covered two or three times but with limited reference to underlying models of charge flow.	A review of the elements forms part of the curriculum across a number of years. The increase in sophistication with each year largely depends on an increase in the number elements covered.	Ecological inquiries feature increasingly complex, quantitative measures of species density and abiotic factors. These are linked to a growing understanding of energy flow through the ecosystem. The mathematical concepts and skills required are developed in synchronisation with the mathematics curriculum.

Sufficiency of coverage			
Criteria	• There is a lack of key ideas and little development of difficult concepts. • Much of the science is couched in common sense terms avoiding key content. • The choice of material appears random.	• A balance of content and conceptual material. • Some topics are covered at a fairly shallow level while others are explored in some depth. The choice of which to 'introduce' and which to 'develop' is made explicit or appears to follow a clear rationale.	• The science present is too detailed across too wide a field. • Much of the content requires extensive memorisation and encourages a didactic teaching approach 'to get through it all'. • Notably absent is space for thinking and synthesis.
Exemplars	Students explore the issues around electricity generation and the effects on the population living near power stations. However, much of the material is economic and societal rather than scientific.	Students are exposed to ideas about evolution in primary school through looking at the adaptations of a variety of plant species. These are developed in future years through work on survival of the fittest and population dynamics.	Students are required to memorise vitamin and mineral contents of foods but have no exposure to the idea that vitamins and minerals are required in very small amounts compared with protein, carbohydrates or fat.

Sophistication of skills			
Criteria	• Skills identified are largely mechanical and manipulative. • The clear intent is that students will be instructed in the procedures and when to deploy them.	• Skills are more varied and included planning inquiries etc. • Inquiries tend to be heavily scaffolded and directed. • Purpose of skill deployment is supplied by the teacher.	• Skills range from simple mechanical tasks to management of multiple lines of inquiry. • The purpose of the inquiry is provided by the student along with the eventual use of any knowledge generated.
Exemplars	Measure the gas given off when zinc dissolves in sulphur acid.	Plan an investigation to compare the porosity of two pieces of fabric.	Fresh fruit shipped from growing areas to the major export ports are showing a high level of damage. Identify issues that might affect this, explore them and produce a recommendation to the growers and hauliers to reduce wastage.

Interpreting the tool results

Although the tables provide descriptors for each dimension at three 'levels' these are designed to provide a stimulus to discussion and reflection rather than an attempt to convert necessarily complex and messy qualitative perceptions into simple quantitative data. They are *not* scores and not all dimensions are equally weighted.
However, taken overall, the assessment should highlight areas of concern and sources of strength. Note also that there is no 'perfect' end of the table - in some circumstances an intelligent curriculum developer might want to be on the far right of the table and others on the far left or in the middle.

Exemplar results and commentary

Cultural relevance		
		• Earth Sciences show clear links to Philippines place in the world by reference to 'ring of fire' and volcanoes. • Meteorological work looks particularly at monsoons and other relevant weather events. • The biology work includes references to caring for animals which fits well with a country that has a significant rural population.

Conceptual coherence		
	Curriculum is based on a spiral approach with good links from year to year. No links are visible with mathematics curriculum and some topics seems to disappear in certain years.	
Sufficiency of coverage		
		The curriculum appears over-loaded with a large number of examples but limited exploration of key ideas. A number of topics at SHS level seem unnecessarily detailed or have limited conceptual benefit (e.g. Gauss' Law)
Sophistication of skills		
Limited evidence of inquiry skills in the curriculum document. Where mentioned they are often separated out so there seems to be little need to engage in whole investigations.		

The analysis above is a very simple first look at the curriculum to illustrate how the tool may be used. In a workshop setting, with multiple inputs from a range of teachers and educators, the analysis can be considerably richer. However, even from this initial exercise it is clear that the strengths of the Philippine curriculum are in cultural relevance while there may be some need to look again at the place of inquiry skills.

Appendix 3: Curriculum Trends Tool

When and why to use this tool

This tool plots the relative positions of key concepts in a science curriculum and compares this with curricula from other countries. It identifies key material common to most curricula. These items are typically conceptual involving ‘x is related to y in some way’ (survival of an individual is related to its particular adaptations to its environment) allowing students to use the idea to make predictions rather than simple content statements (the melting point of ice is $0^{o}C$).
Scientific method is not assessed in this context although it would be possible to develop similar concepts for that area, e.g. a change in an observed output variable in a properly controlled experiment will be linked to the modification of an input variable.

Key concepts

Discipline	Broad topic area	Key concept
Biology	Cell biology: differentiation.	The structure of a cell and organ is linked to its function in the body.
	Natural selection	The survival of an individual depends on its adaptations to the environment.
	Energy transfer	The supply of energy in an ecosystem depends on the activity of the primary producers (green plants).
	Variation	The characteristics of offspring depend on the genetic material supplied by the parents and the environmental effects on its expression.
Chemistry	Atomic structure	The chemical properties of an element depends on the configuration of electrons in its outer shell.
	Kinetic theory	The rate of evaporation depends on the energy supplied to the liquid.
	Material properties	The macroscopic properties of a compound depends on the nature of the bonds between the atoms.
	Earth science	Feedback systems within the biosphere tend to reduce the effect of any disturbance to the system.
Physics	Electricity	The current flowing in a conductor depends on the potential difference across it and the resistance of the connection.
	Gravity and forces	The gravitational attraction between two bodies depends on their masses and the distance between them.
	Wave theory	The movement of individual components in a medium is small compared with the movement of a wave through the medium.
	Energy	The transfer of energy between stores typically involves the loss of some of the energy as heat.

How to use this tool

1 Identify the content statements or descriptors that relate to each of the concepts below in your curriculum. You may find it useful to distinguish between the first appearance of the relevant content in a curriculum and the point at which the full import of the concept is developed.
2 Plot the introduction and development of the concepts on the graph below. The horizontal axis indicates the relevant school year.

Key concept	3	4	5	6	7	8	9	10
The structure of a cell and organ is linked to its function in the body.								
The survival of an individual depends on its adaptations to the environment.								
The supply of energy in an ecosystem depends on the activity of the primary producers (green plants).								
The characteristics of offspring depend on the genetic material supplied by the parents and the environmental effects on its expression.								
The chemical properties of an element depends on the configuration of electrons in its outer shell.								
The rate of evaporation depends on the energy supplied to the liquid.								
The macroscopic properties of a compound depends on the nature of the bonds between the atoms.								
Feedback systems within the biosphere tend to reduce the effect of any disturbance to the system.								
The current flowing in a conductor depends on the potential difference across it and the resistance of the connection.								
The gravitational attraction between two bodies depends on their masses and the distance between them.								
The movement of individual components in a medium is small compared with the movement of a wave through the medium.								
The transfer of energy between stores typically involves the loss of some of the energy as heat.								

Interpreting the tool results

A line going the key points will give a graphical representation of the conceptual loading of each discipline at each year. So, if the biological concepts are introduced much earlier than the chemical or physical ones this reveals a conceptual leaning towards life sciences.
To compare a particular curriculum with another use two lines in different colours to provide an instant picture of the relative demands of the two curricula.

Exemplar results and commentary

Key concept	6	7	8	9
The structure of a cell and organ is linked to its function in the body.	🇬🇧	✅		
The survival of an individual depends on its adaptations to the environment.		✅🇬🇧		
The supply of energy in an ecosystem depends on the activity of the primary producers (green plants).	🇬🇧		✅	
The characteristics of offspring depend on the genetic material supplied by the parents and the environmental effects on its expression.		🇬🇧		✅
The chemical properties of an element depends on the configuration of electrons in its outer shell.				✅🇬🇧
The rate of evaporation depends on the energy supplied to the liquid.	🇬🇧		✅	
The macroscopic properties of a compound depends on the nature of the bonds between the atoms.			✅	🇬🇧
Feedback systems within the biosphere tend to reduce the effect of any disturbance to the system.			🇬🇧	
The current flowing in a conductor depends on the potential difference across it and the resistance of the connection.	🇬🇧	✅		
The gravitational attraction between two bodies depends on their masses and the distance between them.	✅🇬🇧			
The movement of individual components in a medium is small compared with the movement of a wave through the medium.		✅🇬🇧		
The transfer of energy between stores typically involves the loss of some of the energy as heat.	✅🇬🇧			

The green ticks show the position of these concepts in the Philippines curriculum. The exact positions are open to debate and the best analysis will involve a group of people working independently and then reaching a consensus. The absence of a tick means the concept could not be found easily in the curriculum document. The British flag symbol shows the position of the relevant concepts in the UK document. Since the UK does not specify which year a topic should be covered in the flags are markers for typical years. The UK year groups have also been adjusted to reflect the earlier start to formal schooling in the UK.

A more complete picture would involve an analysis of a number of curricula to identify trends and offer guidance on when the Philippine curriculum was significantly out of step with other curricula. This does not mean that the Philippine curriculum should be changed but may suggest issues to consider when thinking about the demand of topics and whether they are appropriate in each year.

Appendix 4: Lesson Focus Analysis Tool

When and why to use this tool

This tool looks at the details of an individual lesson to assess its focus. It is not suitable to analyse a series of lessons or an extended teaching plan. It does not assume a particular teaching strategy or lesson creation model (e.g. the 5E model or starter-main-plenary structure).

How to use this tool

1 Imagine you are a teacher working outside your particular discipline. Using *only* the supplied lesson plan and teaching resources fill in the questionnaire below. This will ensure you produce a realistic analysis rather than 'filling in the gaps' in the plan with your own teaching and subject knowledge.

Component	Issues to consider
The key concept *One per lesson is probably enough!*	What is the central concept / big idea in here? e.g. *X* is related to *Y* in this way. How difficult is this concept/big idea? Familiar, concrete and obvious or exotic, abstract and surprising?
Lesson content *What will you cover?*	What examples will you use to help students develop this concept? 1 2
Distractors *What will stop them getting the key concept?*	What else do students need to know to 'get' the central concept? How could they distract from the central concept?
Tasks *What will they do?*	What will your students do? How will these lead to the central concept? How can you help to smooth their path?

Component	Issues to consider
Evidence *How will you know they have succeeded?*	What will students do to show you that they understand? How will you grade / validate this?
Lesson flow *When could things go wrong?*	What are the ‘heavy demand ‘ points? How can you help students to get through these?
Reality check *How does it feel to you?*	So, how convinced are you that this lesson plan will work? Does it have enough time?

Interpreting the tool results

Many of the questions will produce answers which require little interpretation. If answered honestly the tool should identify key issues with a lesson and allow writers to modify and improve as appropriate.

Appendix 5: Teacher Guides Review

These comments refer to specific Lesson Plans. A number of the comments are valid across a range of plans but have only been mentioned once to avoid repetition.

Mathematics

Unfortunately the mathematics lesson guides were not made available until the day of the conference so it was not possible to review them in advance. They are quite different in style from the other lesson guides—looking more like a textbook than a plan that a teacher might follow. There are few instructions for the teachers and they do not always follow the teaching guide template (Introduction to Evaluation sequence). However, they are clearly highly supportive and a valuable tool in the absence of a more traditional textbook. The material reflected the curriculum well covering a number of topics in a sensible sequence.

Chemistry

A number of Lesson Plans were supplied prior to the conference and were analysed in advance. These were also unpicked live with chemistry colleagues in an informal workshop.

Chemistry 1: Geometry Of Molecules And Polarity Of Compounds (Lecture)

It was not easy to discern the central concept of this lesson since a number of issues seemed to be raised: polarity of bonds, covalency and geometry of molecules. The examples chosen to illustrate some of these ideas were also difficult to link to the central concept. The introduction of the term ‘supercritical fluid’ and carbon dioxide gas in the Enrichment section added more ‘conceptual noise’ - obscuring the central message rather than supporting it. The group agreed that a tighter focus would improve this lesson.

Starting the lesson with a selection of high demand vocabulary seemed to create difficulties from the first few minutes. The need to include terms like Valence Shell Electron Repulsion (VSEPR) Theory at the start of the lesson when students did not know what it meant anyway was questioned. A gentler introduction to the lesson might make it more inclusive and supportive. The Teaching Tips in the right hand side column were useful.

Chemistry 1: Geometry Of Molecules And Polarity Of Compounds (Lab)

This seems much more approachable than the lecture lesson that accompanies it. Unfortunately a number of the resources were not available (lab sheets etc.) so SIoE researchers could not see how the lesson would actually play out and how the students would make the connection between the laboratory activities and the conceptual material in the lecture lesson.

Sharing Enrichment and Evaluation (EE) activities with another lesson has potential but exactly how this would be managed needs clarification. Do the teachers begin in one lesson and continue through the other? Or do they do the same in two different lessons? It might be useful to consider giving the laboratory work a real world purpose. Why might it be important, in a societal sense, to find out what the students are going to look at today? What is the benefit to people and society of knowing which liquid dissolves which solid? What is the purpose of this work?

Chemistry 1 : Properties Of Ionic Compounds (Lecture)

The lesson appears to cover properties of ionic compounds (macroscopic, readily observable) and relate these to microscopic structure. Unfortunately the lab sheets were not supplied so we could not assess these. While labelled a lecture it is obviously a practical session. The real world example (spreading salt on icy roads) seemed out of place in the Philippines – a more relevant example would, perhaps, be more appropriate.

Chemistry 2: Macale Bronsted Acids And Bases And The Acid-Base Property Of Water (Lecture)

The central concept, that some substances can act as bases or acids, is clear throughout the lesson. There is a good focus. The use of the hammer as an analogy will also be helpful to students. Analogies generally can be useful teaching and learning tools - particularly when students develop and explore them themselves. The right hand column provides a very useful set of instructions for the teacher.

The evaluation activity would be strengthened if there was some work in the lesson about the importance of the acid-base property of water. The idea is described, and well explained, but there appears to be no link to anything of significance. This could be improved by showing the importance of this material to biological systems, enzymes etc. This would then allow the students to have a go at the evaluation activity. The criteria for assessment need clarification - how many concepts will be covered in the poster?

Earth and Life Science

Earth Science 2 - Introduction to Life Science - Tabugo

This lesson was estimated at 120 minutes and would probably be reasonable in that time frame. During discussion in the review group it was agreed that splitting it into two lessons of one hour was more realistic and would also allow a clearer focus for each activity. The first lesson would look at what was described as the historical development of the concept of life. Unfortunately the ‘concept of life’ has a rather variable definition in that it could mean everything from the characteristics of living things through to the ‘meaning’ of life in a philosophical or religious sense. After discussion it was agreed that the key focus should be clearly defined as 'biological', looking at the characteristics of all living things (respiration, excretion, nutrition etc). Once this was clarified it became possible to complete the lesson analysis.

Following on from this clarification the first section would need modification. While an initial discussion about ‘what does life mean to you?’ can be useful as a way to gain students’ interest it was felt that this should move fairly quickly into more scientific discussions about the distinction between alive, once alive (dead) and never alive (inanimate). The use of photographs to explore the characteristics of living things was considered a useful strategy but students needed to be guided fairly quickly to the key general processes (respiration, reproduction, nutrition, excretion etc.) and away from particular incarnations (blood flow in rabbit ears, Venus fly trap plants digesting insects, floral structure etc.). A review of the variety of life, choosing dramatic or surprising examples, would help but would need careful management and may be confusing in the context of this lesson. Possibly it would form a good follow-on lesson or project where students could show how different organisms solve their particular problems concerned with nutrition, reproduction, respiration etc.

The notion of ‘unifying themes in the study of life’ was considered to be potentially less than useful as different scientists may identify different unifying themes. The phrase ‘study of life’ rather than ‘life’ is the source of confusion. Biochemists will identify very different themes from environmental geneticists or plant anatomists or parasitologists and medics. These different themes and approaches might form the basis of an interesting discussion with able students if time was available but is probably not useful in a time-constrained teaching and learning sequence for general students.

The second lesson then focusses on how non-living materials can, in some way, give rise to living things. Effectively this is the study of the origin of life. Using groups to explore the different theories is a good strategy and the poster and gallery walk suggests a good way to require students to actively construct their knowledge and understanding by making it visible to others. However, there were issues with the number and nature of the possible groups. It is likely that ten topics is too many and some of the topics are probably best avoided (special creation) or not about the origin of life (fossils, geological time scale). If ten topics were covered students would be limited to perhaps 2 minutes per topic during the gallery walk (clearly not enough time to gain a proper understanding) and some students would have only studied in depth topics that were not helpful to their understanding (special creation). A better strategy would be to limit the topics to three or four. If these modifications were made the group agreed that the lessons would be very enjoyable and productive.

Earth and Life science - History of the Earth 1

This lesson guide has a clear learning focus that was illustrated by a useful concrete experience (building of the shoebox Earth model) which offered a clear link to the central concept that the ground is made up of layers laid down sequentially over geological time.

The conceptual background to the task may need further development to maximise the learning payoff. For example, there was no reference to the notion of sediments and sedimentary rock although none of the activity was relevant to igneous rock. Similarly the understanding could be extended by considering the effect of events like volcanic activity or erosion which could fold or modify the layers.

The lesson was seen as appropriate and productive. A good combination of a simple activity that linked to a more abstract concept which offered a number of opportunities for further development (relative ages of rock start, dating of fossils, reconstruction of past climates and events etc).

Physics

General Physics II: Electric Flux and Gauss’ Law

This lesson guide was well structured in the sense that it showed teachers how to deliver the required material and identified misconceptions, mistakes and difficulties the students might face. The plan also suggested strategies to overcome these difficulties. Unfortunately the lesson appeared to have no purpose and when the question was raised both SIoE researchers and the writers could not identify a specific reason to include Gauss’ Law beyond the fact that it was in the curriculum. There did not appear to be any useful application of Gauss’ law that could be identified in the time the researchers and writers reviewed this lesson guide.

This raises a significant point. The curriculum is already over laden with content and this lesson, which is more mathematics than physics, is taking up valuable time which could be used to cover physics concepts which are more useful. After extensive discussion the group came to the decision that the content this lesson guide had to cover was less than immediately useful or accessible and, given the need to cram a curriculum designed for 80 hours into 60 hours, the group were concerned that many teachers would just ignore it. However, it should be noted that the author had produced a very coherent lesson guide. The fact that it would be possible to complete the activity and get all the right answers and still not understand any of the physics about charge is a significant problem. This is a maths lesson but the physics understanding developed by it is likely to be small. This is a general problem with a number of the physics lessons. The switch to a mathematical treatment mat means that mathematicians can 'pass' the physics courses, because of their facility with calculations and algebra, but still have no understanding of the real physics underlying it. Alternatively, good physicists who may not find the mathematics so straightforward could drop out even though their understanding of the physical principles underlying the work was very good.

General Physics 1: Conservation of linear momentum and the types of collisions

This lesson was planned for 120 minutes. Since few schools will probably have lessons this long it was considered sensible to split it into two lessons.

The introduction starts well by requiring teachers to ask questions as opposed to merely tell students what they need to know as with some other lesson plans. The lesson progresses well in a coherent pattern but is probably over-dominated by a mathematical treatment of everything. It would be beneficial to have some activities that require students to use their physics as opposed to their mathematical understanding to solve problems.

It was not clear where the lesson might split into two. This point is true about a number of the lessons but was particularly clear here. The textbooks referred to in the resources are university level texts. The new SHS level is not university level, it is preparation for university and use of, or apparent endorsement of, university level textbooks in the lesson plans might lead some teachers to misunderstand the appropriate level for instruction.

General physics 1 Centre of mass, impulse and momentum

This lesson guide was listed as a 60 minute lesson which was agreed as reasonable by the group within the workshop. The flow of the lesson would benefit by some reformulating. Rather than leading with rigorous definitions and mathematical treatments, which can obscure rather than clarify the meaning of the lesson for many students, it would be better to start with the egg-throwing challenge. Encourage students to talk about what they notice during the activity and then draw these 'common sense' perceptions into a more rigorous, scientific statement with a full mathematical treatment. A similar rearrangement would benefit the evaluation section. Begin with the question about Pacquiao's boxing match and get students to puzzle out what they expect to happen and then check. This is a good scientific inquiry skill—making and testing predictions. The mathematical treatment given in the other questions then helps to formalise the understanding. This use of real life interpretations and analogies was mentioned in the teaching tips so the writers should be encouraged to do more of what they know to be effective.

Physical Science: The Earth and its position in the Universe

This lesson guide packs a great deal into 60 minutes. It is well structured and the plan supports the teacher. The summary of the lesson at the front is useful and there are many references and links to resources throughout. However, in a curriculum that is generally agreed to be content laden it is worth reflecting on whether the material covered is worth doing.

Most of the lesson discusses incorrect and potentially misleading ideas which could well confuse students as they try to move on to more modern ideas. On page 6 the plan makes reference to the, incorrect, Greek belief in the need for ‘a constant intervention (e.g. force) to keep things in their original state or condition’. This is unhelpful as it may strengthen a common, modern misconception about movement of an object - that to keep a body moving a force needs to be constantly and continually applied. Students find it difficult to understand how a force can make a body move in friction-free conditions and that that body will continue to move at constant velocity unless another force acts. Therefore, the emphasis of this idea, however tangentially, through reference to the ancient Greeks is not useful. This problem is caused by the curriculum needing to discuss Greek science rather than the lesson guide (which covers the material sensibly) but it illustrates a potential problem. If one considers that many of the teachers actually delivering the lesson will be non-specialists it is easy to see how misconceptions could be planted *by the science lessons* which could take years to uproot.

The notion of science as a body of ‘known truths that develops and expands over time’ is also questionable. Science is a series of guesses and predictions that we have, so far, failed to disprove. They are not ‘known’ but merely ‘accepted at the moment’. The suggestion that physics grew out of Greek astronomy and philosophy also supports the notion of gradualism—that science progresses in an orderly manner, building on what has been before. An alternative, and popular, view sees science as series of revolutions where change can be sudden, unexpected and, occasionally, in conflict with previous ideas. While a discussion of the nature of science is outside the scope of this document it is worth pointing out that this lesson guide does promote a gradualist, Euro-centric model of science which may build attitudes in students that will inhibit their willingness to propose new and revolutionary ideas. This is unlikely to support entrepreneurship or creativity.

General Physics 1: Newton’s Laws of Motion and Applications

This lesson guide plans to cover 60 minutes which seems reasonable. The introduction to the lesson plan was useful—a quick guide to the material that is to follow. The teaching tips were also useful pointing out common misconceptions that teachers should watch out for. The flow of the lesson could be improved by starting with concrete examples and working towards the general, abstract treatment of the material rather than starting with this and introducing applications afterwards. Students would benefit from greater direction than simply ‘ask them to discuss the following questions’ (Enrichment p 5). Are they expected to discuss and then answer? Or merely discuss? What is the output for this task?

The evaluation is also a series of Yes/No questions which can be answered correctly 50% of the time even if you know nothing. These are better avoided or, if they are used, are backed up by a supplementary question asking students to justify their choices.

Biology

Biology 1: Energy transformation

This lesson guide is set to run across four hours. This would equate to almost two weeks work in the UK so it is likely that the guide would benefit from being split in to smaller, more focussed lessons each lasting an hour. Additionally, the connections between these lessons and the learning pathway for the students need to be clear.

The lesson guide starts with a good introduction. The teacher is told to question students about typical applications of fermentation and respiration that they will already be familiar with. This is a good way to identify connections for the students' about the material to follow. Unfortunately, since the lesson is so large the range of possible applications is perhaps a little too wide. So, the introduction starts with the products of fermentation and then goes on to discuss energy drinks, carbo-loading and vitamin b-complex supplements. The clearer focus afford by splitting the lesson into 4 lessons would help solve this problem. The lesson then continues with a series of tasks but with little support. These will be fine for competent biologists but maybe demanding for teachers working outside their specialism or who are used to working at a lower level. More support might be useful, a set of diagrams illustrating the main metabolic pathways and the notion of the metabolic pool. Most of the lesson (160 minutes for practice) needs greater direction and support for the teacher. The enrichment section which is given five minutes particularly looks very demanding in the time available. To say that this work can be done at home is probably not enough. The teaching tips add extra explanation but few tips for teachers in terms of delivery. This could be expanded.

Biology 1: enzymes

This lesson guide was set to run for two hours. Given that it potentially includes a significant lecture on enzyme structure and enzyme-substrate complexes as well as a practical investigation this seems reasonable. Again, it might useful to split into two lessons to improve the focus for both. The conditions the students will investigate with the liver experiment are not given. Some suggestions about the factors they will change might be useful, for example temperature or pH. The directions in the main column are helpful and show a logical flow to the material. It is assumed by the reviewer that much of the material will be familiar to students from previous lessons as a great deal is covered in a short time. The use of models to illustrate enzyme-substrate complexes and enzyme activity is useful but more guidance on how to draw out form these explanations of observable phenomena might be useful.

Appendix 6: Science Teacher Quality Framework

Domain	Characteristics
Professional Knowledge This domain includes knowledge and understanding of the central principles of teaching.	• Teachers have a strong subject knowledge and strong Pedagogical Content Knowledge (PCK). • Teachers demonstrate a critical understanding of current developments in the subject area and their relevance to the curriculum. • Teachers draw upon knowledge of a wide variety of classroom teaching approaches. • Teachers demonstrate strong knowledge of their students learning styles.
Classroom Practice This domain includes the actions, tasks and approaches that high quality teachers engage in during classroom practice.	• Teachers provide a safe, stimulating and challenging environment for learning. • Teachers design, plan and assess/evaluate students learning effectively. • Teachers engage students in learning and promote ownership and responsibility of learning among students. • Teachers select and employ the most appropriate teaching and learning approach for the intended subject matter. • Teachers establish good teacher-student relationships based on mutual trust and respect;' • Teachers manage classes effectively through clear and appropriate rules for behaviour and promote respect and courtesy between teachers and students.
Knowledge of students This domain includes the knowledge that high quality teachers draw upon to ensure students have access to rich and effective learning experiences.	• Teachers have a strong understanding of a range of factors which may inhibit students' learning and know what actions to take to address them. • Teachers know the factors involved in the physical, social and intellectual development of children and know how to adapt/modify their teaching to accommodate different developmental needs.
Professional Commitment This domain includes the activities, actions and processes that high quality teachers engage in to ensure they maintain high standards.	• Teachers engage in Continuous Professional Development (CPD) activity to improve their subject knowledge, PCK and general practice. • Teachers reflect continually in, and on, practice and take actions to address any emerging issues. • Teachers engage as members of their professional and subject communities.

Appendix 7: Personnel

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