The Excellent Science Department

A guide to its leadership
and self-evaluation

SSERC

Jim Stafford

Acknowledgements

Foreword to the second edition

I read this booklet with great interest. I remember writing many years ago a not dissimilar guide to teaching and learning in English and was curious to see how the world has moved on since then. Over the intervening years I have had much to do with the teaching of Science from a range of perspectives, including particularly that of Head Teacher for 15 years. On top of that mix there have been very close links with all the major developments in Scottish education in particular, of course, Curriculum for Excellence and the attendant development of the new national qualifications.

From that perspective then, I think this booklet picks up all the key themes that any aspiring or existing Principal Teacher (or Faculty Head) would wish to have at their fingertips. It sets out best practice across a whole range of aspects of leading and managing a Science department. It is thorough, well researched, tied very much to years of quality experience. It doesn't pull its punches. It deals with the essential aspects of improving young people's learning in the context of a fast changing world with fast changing expectations of its schools and teachers. And Science is at the forefront of that change. Yesterday's model just simply won't do.

But it also recognises that delivering such a challenging remit can only be done through cooperation, collaboration and partnerships. Real people work in these departments with strengths and weaknesses, dealing with young people with a far wider range of need and ability, all of whom must find their place productively in society. To do that effectively, departments need to understand Science's place in the broader curriculum; the challenges, especially these days, of diminishing resources and the pressures senior leadership have of supporting all departments to progress; the research base that now underpins our understanding of teaching and learning; and the significant change to our qualifications structures and content. This will undoubtedly help them to do that.

It is not an easy read but it is a great ready reckoner. It should be compulsory reading for all Science leaders. For teachers starting out in their career, it will give a great insight into the practices they should be seeing around them. For Head Teachers it will certainly give them a heads up on where the next request for resources is coming from! The range of checklists and bibliography will be very helpful to them all.

I commend it to you and hope that in turning to it from time to time, you get a glow of satisfaction in recognising your own success with Scotland's next generation of young people.

Ken Cunningham CBE, *FRSA*
General Secretary, School Leaders Scotland

September 2014

Foreword to the first edition

I am delighted to provide a foreword for this booklet which is designed to be a practical aid to all teachers in the curricular areas of Science.

The practical components of the disciplines are indeed well covered throughout and, most importantly, the provision of the highest quality of teaching and learning exists as a major thread.

It is most appropriate that I am writing this foreword on the day on which the long-awaited guidelines on Science for Curriculum for Excellence are launched. These two documents complement each other and should offer considerable support for you as a teacher.

However this booklet is much more than a Cook's Tour of Science teaching. It rightly emphasises the leadership role for every teacher, the use of appropriate management structures and the need for a collegiate approach by all. It emphasises also the place of Science in the whole curriculum of the school, not as an independent fiefdom but as an integral part of core provision. It stresses the importance of the role of support staff and, finally, it puts self-evaluation firmly in its proper context - that of the provision of quality teaching, learning and assessment.

Bill McGregor,
General Secretary
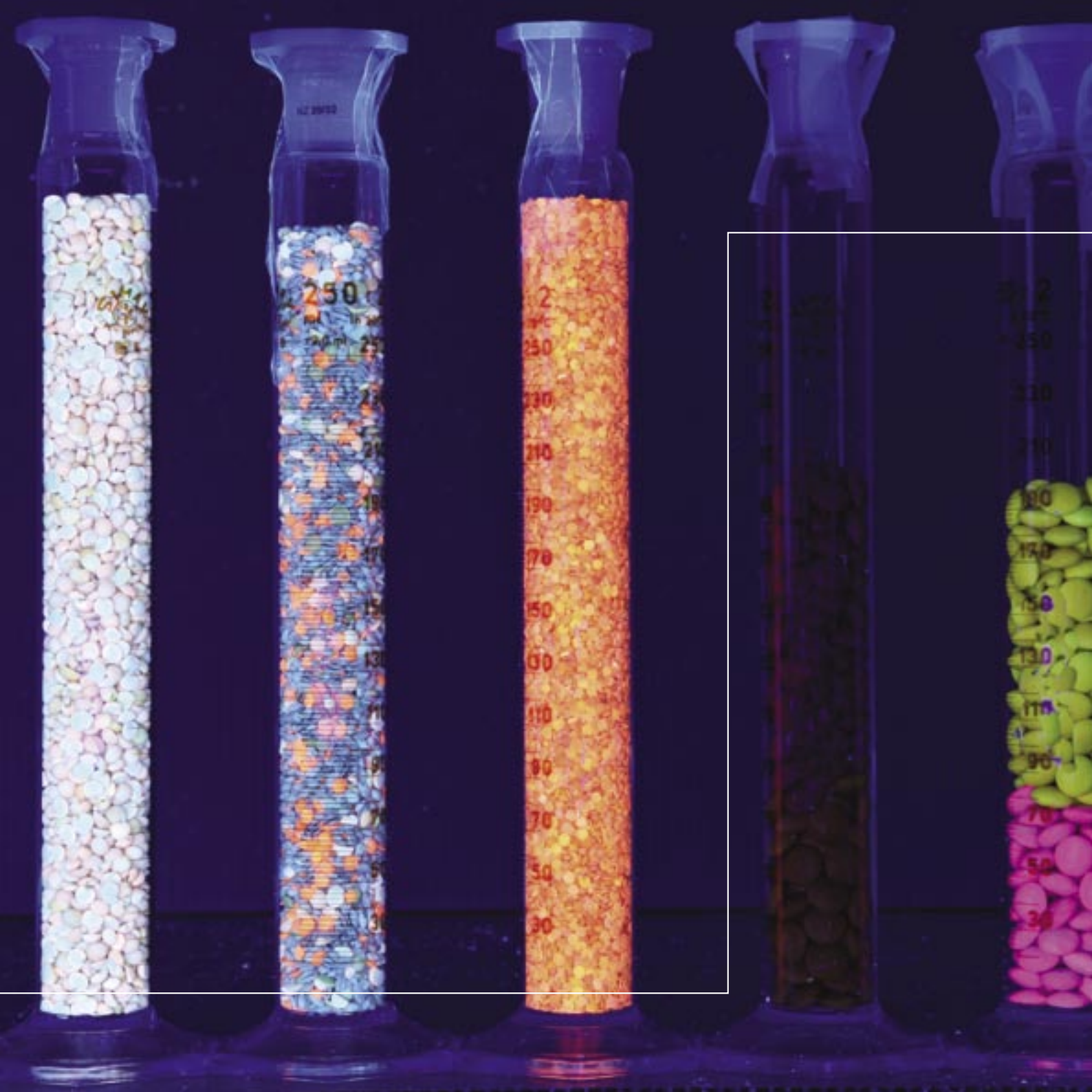*Head Teachers' Association of Scotland*

September 2007

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Introduction

Although this guide will be of particular interest to those who hold promoted posts for science subjects, it should also be valuable to school senior managers, local authority officers and others who have responsibility for the quality of education in secondary schools. It should also be useful to all science teachers as the ultimate aim of leadership and self-evaluation is to improve the quality of the science learning and teaching experiences provided by teachers in school laboratories. It is hoped that this guide can be read from all these different perspectives so that everyone involved in science education can further develop their contribution to the quality of science education in the secondary school.

The aim of this guide is to provide a ready point of reference on the key aspects of leading a secondary science department. This guide is just that. It is not intended to be a comprehensive management manual. Sources of further, more detailed advice are listed in the selected bibliography and can be found in the leadership section of the SSERC website. Since the publication of the first edition of this guide in 2007, there have been significant changes to the science curriculum in Scotland's secondary schools and some 200 teachers have participated in leadership training with SSERC. As a result of these changes and of the feedback from leadership courses, this second edition has been revised accordingly throughout and sections on leading professional learning and developing a leadership culture added.

This present publication has sections on:
• leadership qualities and skills
• the contribution of science to the curriculum
• the management of resources such as laboratories and equipment
• managing health and safety
• self evaluation using data, observation and working in teams
• planning for improvement
• leading professional learning and developing a leadership culture.

The appendices are designed to be used as handy points of reference when leading development work and self evaluation.

1

"Leadership is the special energy we put into our work that makes a powerful difference. Leadership can be applied to every aspect of work. Many people who fail to demonstrate leadership simply don't have their hearts in it. Leadership requires much more than being smart and in charge."

Lisa Haneberg

Leadership

All effective science subject leaders have the confidence and support of their staff. They should lead by example and their teaching should be a model of good practice. They should develop consistently high levels of teaching and pupil attainment in the department and lead its self-evaluation.

1.1 Promoted post structure

As well as the qualities of leadership described above and in Appendix 1, the science curriculum leader has to take responsibility for the delivery, development and quality assurance of the science curriculum. When deciding a promoted post structure to manage science education in the secondary school it is important to ensure that the structure promotes effective leadership. Although a teacher of biology, chemistry or physics should be able to lead developments in their own subject, a Head of Faculty may not necessarily be able to do so. This may then lead to tension within a faculty or department as responsibility for subject leadership is expected of someone who receives no extra remuneration for doing so or, alternatively, someone has an opportunity for professional development that is being denied to others.

> *"Management is doing things right; leadership is doing the right things."*
>
> *Peter Drucker*

In secondary schools where leadership in science is provided by principal teachers of biology, chemistry and physics, the holders of these posts should be well placed to provide effective leadership through bringing their subject expertise to bear on the delivery, development and quality assurance of learning and teaching in their respective subjects. In these circumstances decisions will require to be made about the responsibility for strategic leadership of all science courses as a whole as well as corporate responsibility for science provision in the Broad General Education. In any event the promoted post structure for science in a secondary school must be able to demonstrate planning for effective leadership across all science disciplines as well as science as a whole.
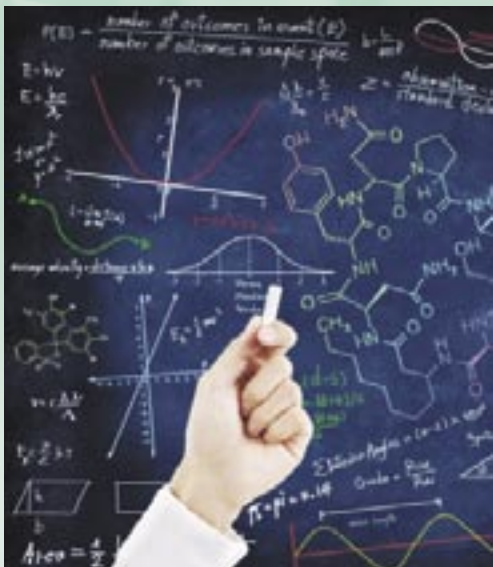
1.2 Delegating responsibilities and tasks

Where responsibilities are delegated to an individual teacher they should be specific with a clearly defined remit. This remit should be known to all members of the department, perhaps by being included in the departmental handbook. A promoted member of staff who has the appropriate knowledge and skills should be allocated to support that teacher in discharging their remit and to evaluate progress. In this way authority is delegated to the teacher to carry out the work while a promoted member of staff retains overall responsibility. Regular meetings should take place to review progress between these two teachers. Teachers with delegated responsibilities should lead other members of the department in developments and share progress with them.

Rotating responsibilities around staff can help to spread ownership and promote teachers' professional learning. The fresh eye of someone new to the responsibility can also help in continuing to improve provision. Where responsibilities are rotated the teacher should hold the responsibility for long enough to make specific progress and to master their remit. Occasionally a teacher may have an interest in a particular specialist subject area that other teachers cannot provide and become the sole teacher for that area. This can make a valuable contribution to the work of the department although it may not be possible to continue with it if that teachers leaves.

Tasks are of a much shorter duration and more highly focused than responsibilities. They will probably be linked to the departmental development or improvement plan and have specific outcomes and associated success criteria. Delegated tasks should be part of an overall plan designed by principal teachers and should be specific, measurable, achievable, realistic and timed (SMART). Again progress in tasks delegated to teachers should be supported and monitored by a member of staff with appropriate skills and knowledge.

> *"The best executive is the one who has sense enough to pick good people to do what he wants done, and self-restraint enough to keep from meddling with them while they do it."*
>
> Theodore Roosevelt

As well as organising the work of the department, delegated tasks and responsibilities widen the experience of teachers and add to their professional learning. In addition to delegating tasks to individuals, delegating tasks to small groups can be particularly beneficial. Groups drawn from different disciplines and involving other specialists, for example learning support staff and technicians, can be very effective. They help to develop common ownership and commitment. The principal teacher should ensure that sufficient resources (including time) are allocated to staff with responsibilities and tasks to allow for their successful completion.

1.3 Communication

Much useful communication occurs informally. A staff base which provides a suitable work area for teachers and technicians with some recreational facilities can greatly assist communication and help to develop a corporate identity for the science department. More formally, communication can be achieved through a departmental handbook and science team meetings. These are important in fostering commitment and shared ownership from all members of staff. A handbook is also valuable as a point of reference for new and temporary members of staff, including supply teachers.

A departmental handbook with policy statements, which have been agreed through consultation and discussion, will help to encourage implementation and best practice. The handbook should give a broad vision and aims for the department's work as well as detailed information on learning and teaching approaches. This could include specific learning objectives and detailed practical advice on teaching approaches, suitable resources, safety, differentiation, homework, correction, assessment and recording, work of technicians and timings for course topics and units. Annotating pupil course materials with detailed learning and teaching guidelines for teachers and technicians can be an effective means of communicating such information. It can also help keep the handbook to a manageable size. A list of possible items that could be included in such a departmental handbook is given in Appendix 2.

"The most important thing in communication is hearing what isn't being said."

Peter Drucker

Departmental meetings should have a set agenda, some items on which may be standing agenda items. A note of meetings should be kept that records decisions taken and action points decided. Regular and well conducted meetings allow teachers to influence departmental policy and practice, contributing to an ethos of teamwork and corporate identity. Meetings should deal with strategic issues related to learning and teaching. Administrative and procedural matters can often be communicated by other means. Meetings should provide opportunities for staff to evaluate progress or practices, discuss future actions and share good practice. Technicians should attend meetings where items may relate to their remit and meetings should be rotated between science and the separate science disciplines.

Curriculum and Courses

Science education aims to provide all learners with knowledge and a basic understanding of scientific phenomena for living in our advanced technological society. It equips learners with the scientific skills to evaluate environmental, scientific and technological issues and to develop informed, ethical views on the impact of them on themselves and the society of which they are part. While judgements and interpretations of scientific evidence may be disputed, honesty and integrity are expected of scientists in making decisions. Such qualities also need to be fostered in young people.

"Children are naturally venturesome and curious."

from an early safety in science education guide by the then Department of Education and Science.

Children have an innate inquisitiveness about themselves and their surroundings which good science teaching can exploit. Their curiosity can be channelled into a life-long commitment to observe and question, to be receptive to new ideas and to be careful in making judgements. Science also provides a context for the development of other qualities, including respect for living things and their environment, an appreciation of the place of humans in the world and an awareness of the contribution of science to the social, economic, cultural and industrial life of the community.

"The curriculum should be designed to convey knowledge which is considered to be important and to promote the development of values, understanding and capabilities. It is concerned both with what is to be learned and how it is taught. It should enable all of the young people of Scotland to flourish as individuals, reach high levels of achievement, and make valuable contributions to society."

Curriculum for Excellence Review Group, Scottish Executive, 2004.

Science education also has to provide the basis for those learners who wish to further their science education beyond school or to seek employment in the science based industries and professions. While the case for science education is fully justified in terms of the educational needs of individuals, our society must also have a constant flow of qualified people with sufficient knowledge and expertise to monitor and develop the technologies on which modern life depends. The vast expansion

of scientific knowledge has led to the need for an increasing degree of specialisation as studies progress. At the same time skills and findings in one subject area are often of vital importance to another and the formation of inter-disciplinary teams is a common feature of modern industry and research work.

To contribute effectively, specialists in such teams require a basic knowledge of other subject areas. As the curriculum progresses through the school, it should not only reflect that increasing degree of specialisation in science courses but also provide opportunities to maintain study across the range of science disciplines.

> *"Science and the application of science are central to our economic future and to our health and wellbeing as individuals and as a society."*
>
> *CfE Sciences principles and practice*

In planning a school's science curriculum, courses should take appropriate account of and build on learners' prior experience, progress and attainment. They should be planned to maintain an appropriate pace to ensure steady progress with periods of time for revision, whilst avoiding mere time filling and unchallenging activities.

Courses should have clear learning objectives and assessment criteria which are shared with learners and used to guide teaching. Content should be reviewed regularly to make it relevant, challenging and interesting. Data should be gathered from first hand experience of experimental work in preference to textual or electronic sources. Recent scientific developments should be included to show their applications, with both their benefits and risks to society. Practical work should be used to enhance knowledge and understanding as well as to develop investigative and problem solving skills.

2.1 Courses in the Broad General Education

Courses in the Broad General Education should maintain Scotland's commitment to science being part of the curriculum for all learners and to building a foundation for later specialisation. As a result learners should enter the Senior Phase from a position that will lead to improved attainment.

Science courses should take account of learners' prior learning in primary school, including their skills in literacy and numeracy. Science departments should work closely with their associated primary schools to develop a coherent programme of study in science. This should do more than agree which experiences and outcomes are taught at each stage. It should allow for the progressive development of science thinking and problem solving skills. Science experiments, activities and investigations should become increasingly complex to maintain an appropriate level of pace and challenge. At the same time the progression in learners' numeracy and literacy skills should be developed through data handling exercises and recording and reporting activity (including scientific report writing) associated with their scientific work.
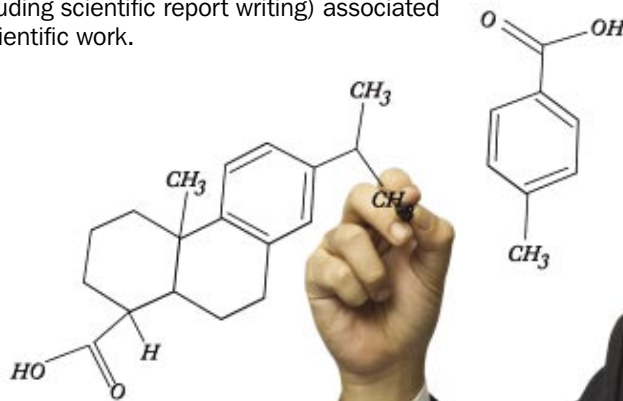
When developing science courses, the experiences and outcomes should be used to plan for coherence and progression in programmes of study rather than be viewed as a curriculum to be covered. The aims and goals of the broad national framework of Curriculum for Excellence are intended to be applied flexibly to suit local circumstances. Science courses should develop scientific literacy and allow for progression in learning through developing breadth, challenge and application in science learning [1]. It is within that context that the learner's entitlement to the experiences and outcomes should be met. All learners should experience the science experiences and outcomes up to and including the third level and have access to the fourth level where these are consistent with their prior achievements, learning needs and aspirations.

Access to fourth level science experiences and outcomes should not be restricted to optional course elements nor should the choice of options restrict a learner's potential access to all of the fourth level science outcomes and experiences. Science course options should provide opportunities to further develop science skills in a variety of contexts and to support transition to qualifications in the Senior Phase. Such optional course elements should not be exclusively seen as preparation for qualifications for high flying committed science learners, optional science course provision could also explore contexts for living in a scientific and technological age or to explore vocational opportunities in science. In any event options should not be tied to a particular level; learners should be able to progress to other levels or to consolidate at a level as suits their prior

achievement, learning needs and aspirations. All in all, science learning in the Broad General Education is about providing appropriate challenge so that learners have a strong platform on which to build successfully towards qualifications in the Senior Phase; it should not be about rehearsal and practice of examination standards.

Interdisciplinary learning should be more than a special event, project or course. Learners should have the opportunity to integrate their knowledge and ways of thinking from other disciplines to raise questions, solve problems and offer explanations in science. Equally learners should have the opportunity to apply the skills and knowledge they learn in science to other curriculum contexts. Science Curriculum Leaders should have an overall understanding of the Broad General Education curriculum so that they can provide such opportunities in science and act as an adviser to the integration of science into other curriculum areas.

Science courses should also provide opportunities to develop capabilities of the four capacities of Curriculum for Excellence (Appendix 3) and skills associated with employability, enterprise and citizenship and thinking skills that are part of the Skills for Learning, Life and Work (Appendix 4). Optional course elements can provide excellent opportunities to explore these aspects in depth. The increasing importance of evidence-based medicine in public health and the process of assessing and managing risk are aspects of scientific learning that can be presented in contexts that have direct relevance to the health and wellbeing of learners, their families and communities.

Overall science courses in the Broad General Education should develop the key elements of scientific literacy that will support lifelong learning and enable young people to become effective contributors to society. They are:
- how things work - the knowledge of science
- how science works - how science is done
- making decisions - what is done with science.

The opportunity should be taken during the planning and execution of science investigations and experiments to provide learners with the opportunity to work together collaboratively in small groups. This will give them an insight into how practising scientists use teamwork to meet scientific challenges.

Homework should be clearly linked to course work and be varied, challenging and purposeful as well as reinforcing learning.

Courses should be supported with modern up to date resources, equipment and laboratories which promote learners' first-hand experience of real materials, living things and the environment.

2.2 Courses in the Senior Phase

Learners should be able to choose a range of courses in the science disciplines appropriate for their learning needs and career aspirations. As a result of the totality of education and rounded experience to support lifelong learning of the Broad General Education, learners should now have a freer choice of courses in S4 than ever before. Learners who intend to continue with science education beyond school or to enter a science related career should follow science options in S4 and not delay the choice of a second or third science discipline until S5. As well as courses in Biology, Human Biology, Chemistry and Physics, Skills for Work courses in Laboratory Science, Rural Skills or Health and Social Care could be offered.

Progression pathways should be planned for all learners across S4, S5 and S6 of the Senior Phase. Learners should be embarking on courses at an appropriate level of challenge. Success of learners in gaining awards should be monitored to ensure that learners do not embark on courses that are too demanding for them resulting in no awards. Where Advanced Highers are offered, steps should be taken to ensure that the timetable arrangements allow sufficient time for teaching and learning to take place. Consideration should be given to providing courses for learners who did not follow a particular science discipline in S4 and wish to do so in S5, as should further progression from these courses into S6.

Learners should be able to progress from courses chosen at an earlier stage. The transition from the Broad General Education to the Senior Phase does not present a specific end point. Although most learners will have attained third level experiences and outcomes, many will have also attained fourth level experiences and outcomes and some will have embarked on fourth level learning appropriate for individual qualifications. Progression pathways should have a clear purpose and rationale that accommodates these different starting points and leads to end points that have clear destinations for learners. Progress to science courses in the Senior Phase should articulate to the broad totality and rounded experience of the Broad General Education. Optional science courses in S3 should be a preparation for qualifications in the Senior Phase, not a requirement.

3

"I don't see managers and leaders as different people. We can all demonstrate both management and leadership. We are leaders some of the time and we also need to be managers some of the time."

Lisa Haneberg

Managing Resources

Technicians make an invaluable contribution to the work and management of resources in the science department. The complex and varied resources required for effective science teaching make the support of technicians essential. The quality of pupils' learning experiences is improved when technicians organise equipment, materials and resources, so making these readily available to support learning and teaching. They have an important role in generating cost savings in the repair, maintenance and manufacture of equipment and in the maintenance of safety standards and requirements.

Good relations and communication between teachers and technicians are essential if the science department is to work well. Technicians should have clear remits that are well understood and communicated to all staff, have the opportunity to work on their own initiative and attend relevant departmental meetings. There should be clear routines for the ordering, preparation and maintenance of materials and equipment between teachers and technicians.

Technician responsibilities and duties can include:
- Requisition and stock control of chemicals, micro-organisms, radioactive sources and other science consumables.
- Preparation of chemicals for school laboratories.
- Caring for plants and animals.
- Maintenance, calibration and repair of equipment.
- Organisation and delivery of equipment and materials for specific lessons in school laboratories.
- Setting up practical tests and demonstrations.
- Manufacturing simple apparatus.

Technicians should not be engaged in tasks inappropriate for their training and level of qualification, for example in reprographics or other clerical and general administrative duties.

Technicians should have a suitable base equipped as a workshop and from which to manage the flow of materials and equipment. It should be sufficiently spacious for the safe operation of workshop activity and include a laboratory preparation area. The laboratory bench space should have workstations with the appropriate services for the full range of science technician activity including preparation of chemicals, microbiology work and occasional usage of sealed radioactive sources.

There should be a fume cupboard and a glass clean up area with a large sink. Safety equipment and materials should be to hand. A computer area will be required as will a bench suitable for wood working and other activity related to the repair and maintenance of equipment. In a modern science technician area there is no need for standing equipment such as band saws, pillar drills, lathes and grinders. These items are better located in the technical technicians' area where any tasks necessary for science can be carried out. The technicians' base should be adjacent to central storage areas and other technician serviced areas and facilities as well as the school's laboratories.

3.2 School laboratory design

The design of school science laboratories is an area that Heads of Faculties and Departments may encounter on a few occasions in their careers, if at all. However, more opportunities for designing laboratories are likely to arise with new school building programmes and the refurbishment of existing schools. Specialist advice on laboratory design is available from organisations such as SSERC (Scottish Schools Education Research Centre) and ASE (Association for Science Education). Many laboratories will have to be refurbished and updated if we are to provide accommodation to meet the demands of new courses more closely reflecting the science of the 21st century.

Teachers will have differing views on fixed and flexible furniture but the key elements of design remain the same. For laboratory work a workstation should be serviced with water, gas and electricity and have sufficient bench space for other laboratory equipment including a computer with associated peripherals. Although traditionally two students have worked at one workstation, modern courses which demand individual work for practical assessment or developing practical competencies mean that thought has to be given to providing sufficient space to allow for more individual work. In addition space may have to be provided for experimental work that has to be left undisturbed for some time. As well as for these considerations space is also required to ensure the safe movement of learners around the laboratory and to facilitate the observation of practical work by the teacher.

Laboratory accommodation should also be sufficiently flexible so that learners can undertake written work and other non practical class work comfortably and effectively. Laboratories should be grouped together to allow for servicing from a central technician base and be adjacent to the storage areas for equipment and materials.

3.3 School laboratory equipment (provision, storage and requisition)

Laboratories should have sufficient storage space to accommodate laboratory equipment and materials that are used regularly. Laboratories should be equipped to a common standard and pattern with the equipment and materials required for the courses that are taught in them. For example all school laboratories are likely to be equipped for science courses in the Broad General Education. Beyond that the most likely arrangement is to have laboratories that are also equipped for biology, chemistry or physics. In this way a teacher teaching in any laboratory will know what basic equipment and materials are to hand and where they are located. Practical work is better managed where each teacher has their own laboratory to aid the preparation and removal of materials for practical work, maintain experiments that run over long periods of time and to display the results of class work. Wherever possible, materials for practical work should be in class sets to maximise the potential for individual work.

Equipment and materials that are not used regularly are best stored centrally and organised by technicians. Often this is done on a 'tray' system linked to an ordering system so that equipment and materials for specific practical work can be readily delivered and set up. In such situations the tray not only holds the equipment but also has information about what chemicals or other materials are required to be prepared for the practical activity. This advance planning can make ordering of materials from technicians more straightforward and routine.

Specialised storage will be required for chemicals, micro-organisms and radioactive sources. Advice on storage of all of these categories of kit can be obtained from SSERC. Effective stock control of all of these materials is required so as to avoid holding unnecessary quantities beyond that needed for the current session and to ensure that any expiry dates are not exceeded. Technicians are best placed to manage stock control arrangements. Advice and information on stock control measures and procedures can be obtained from SSERC.

In many science departments practical equipment is coming to the end of its useful life. Scientific advances, new or revised courses and developments in new technology have all added to the need to replace and update laboratory equipment. In addition modern approaches to learning and teaching have increased the need for apparatus suitable for individual use rather than teacher demonstration. A strategic approach to the purchase of science equipment is necessary. Replacement of equipment or the purchase of new equipment is unlikely to be financially possible in any one year, however desirable. A financial plan should take account of necessary annual spending on consumables as well as capital expenditure on equipment. If a programme of over more than one year is required, the time scale must allow for sets of equipment of similar specification to be purchased before specifications change. This will avoid accumulating class sets of equipment with different specifications which may then lead on to problems in the teaching process and for class management.

The requisition of science materials and equipment can be made less of a challenge or chore through good organisation and management. If technicians are managing the stock control of chemicals and other consumables then they may be best placed to advise on requisition needs. In the same way if laboratories are equipped and resourced to a common standard, then the teacher responsible for each laboratory can advise on their requisition needs. If stocks are maintained to meet needs throughout the year, then an annual requisition to replenish stocks will ensure a steady supply of consumable materials. This in turn will make the identification of the funds available for capital equipment clearer.

3.4 Other aspects of science accommodation

Accommodation in science departments may also include facilities for growing plants, maintaining animals and the use and maintenance of school grounds and gardens for environmental work. Advice and information on these aspects of science accommodation can be obtained from SSERC.

A technicians' base and central storage facilities are essential and should be located near to laboratories for effective management of resources. A staff base for marking learners' work, as well as for lesson preparation etc. and used by all science staff allows for informal networking and

discussion. That in turn will help to develop shared responsibility and commitment to the work in science. The staff base should be equipped with the necessary resources such as computers, textbooks and teaching resources and be a comfortable working area with tea and coffee making facilities.

Consideration should be given to having a departmental library of books, software and other materials for the use of learners. This will help support learners engaged in project work and to provide extension reading and activities for those who wish to take their personal interest in science further. Similarly, learners can be involved in the wider work of the department by sharing in the care of plants and animals and by preparing displays of current work within the department. Such displays could include contemporary or contentious scientific issues in the press and media, current work of pupils and classes, themed displays of photographs and video, models, pieces of scientific equipment and other artefacts.

3.5 ICT

Microprocessor technology has had considerable impact on science. Not only as a scientific advance in its own right but also its impact on the quality and performance of laboratory equipment. Thus for science teaching the effects go beyond the use of computers and all that they can provide to a new generation of equipment that improves the nature, range, sensitivity and speed of recording data. All of these can be considered as extending learners' awareness and familiarity with the impact of ICT on life in the 21st century and to be an appropriate use of an ICT budget as well as a science one.

Computers are an essential and integral part of any modern science laboratory. Science departments should have a strategy to provide sufficient computers for scientific work in laboratories. Such a strategy should include provision that allows individual learner access to computers in the laboratory, a display screen suitable for whole class viewing, sensors with associated software and hardware to allow data capture and control technology.

Data handling software should be interactive and involve learners in making decisions about the parameters to be used when presenting data in graphs, charts and tables. Simulations should allow variables to be altered, hypotheses constructed and predictions tested. Learners should be able to access the type of software used in scientific research as part of their learning; for example molecular modelling software and genome databases. Banks of still and

visual images of scientific phenomena should be capable of being accessed readily and quickly to enhance students' learning experiences and understanding.

Other equipment that could be included in a science department's ICT strategy includes capturing data through images on digital cameras. For example video cameras linked to computers could be used to view microscopic specimens, electronic and optical components, small-scale chemical reactions and animal behaviour. USB digital microscopes are also widely available and are versatile, easy to use and relatively inexpensive.

Equipment and measuring devices that use microprocessor technology could also be included in a science department's ICT strategy. Their increased precision and sensitivity means more results can be collected in a shorter period of time reducing the overall time taken for an experiment. Portable data loggers can be used to collect data over long periods of time for subsequent analysis. Where the number of computers is limited, data loggers with associated sensors can collect data for subsequent analysis with computer software. Research has shown that when experimental results are captured and displayed on screen in real time, live to learners, they bring about significant improvements in understanding.

4

Health and Safety

Very few serious accidents occur in school laboratories. It is a tribute to science teachers that their practice is usually safe. However science teachers have a duty to be informed of current health and safety legislation and to abide by it. In many respects, a more major concern is an apparent over-reaction to health and safety legislation. It is a common myth that many procedures and chemicals are banned, whereas in practice such bans are very rare in education. Such misunderstandings can lead to an undesirable reduction in the quality of students' learning experiences.

It is an important aspect of science education that learners are taught to work safely and responsibly. Learners are more likely to meet health and safety requirements if they understand why these are necessary. A code of practice for safe laboratory working, often as a set of laboratory rules, should be on display and discussed with learners. Learners should be trained in good working practices and be made aware of hazards, risks and control measures for specific activities. Learners should be supervised adequately while carrying out experiments and where appropriate have safe practice demonstrated to them before they proceed.

"HSE encourages schools to allow children to experience risk in a managed environment and does not advocate stopping pupils from participating in exciting science experiments, where they can learn first hand the principles of science and develop an appreciation of the hazards and risks. Sensible health and safety means focusing on managing the real risks and going ahead with activities – and it is not about generating mountains of paperwork either."

Health and Safety Executive [2]

The identification of significant hazards, the assessment of risk and the implementation of control measures are important life skills. Science education can play a key role in their effective development through first hand experiences of laboratory practical work.

4.1 Legislative requirements

The Health and Safety at Work etc. Act is designed to protect employees (i.e. teachers and technicians) and others who may be affected by the employer's activities. The main duties of the Act are thus placed on employers who are required to provide safe working conditions, information and training for health and safety and a health and safety policy. The health and safety of learners must also be ensured, as far as is reasonably practicable, under the more general duty of care for non-employees required by the Act.

An employer can delegate tasks and functions relating to health and safety to teachers and technicians. In accepting such functions, teachers or technicians do not themselves become directly responsible in the event of an accident, unless, for example, gross negligence or disregard for employer's instructions could be demonstrated. The employer would still be held responsible, perhaps by having failed to train the employee adequately or by not providing enough resources (e.g. time and money) for the employees to carry out the tasks adequately.

As a consequence of health and safety being an employer's responsibility, policy guidance on these matters is beyond the scope of this guide. Teachers and technicians must always follow their employer's rules and instructions. In the event of an accident, teachers or technicians should not admit liability without first taking advice from their employer, professional associations and/or an independent expert body such as SSERC or ASE (Association for Science Education).

A number of health and safety regulations have been enacted under the Health and Safety at Work Act. These, for example, The Control of Substances Hazardous to Health (COSHH) Regulations, The Management of Health and Safety at Work Regulations (MHSWR) and The Provision and Use of Work Equipment Regulations (PUWER) impose duties on employers to set in place safe systems of working. Details of these and other relevant regulations can be found in Safeguards in the School Laboratory, 11th edition, ASE, 2006.

4.2 Health and Safety policies

Health and safety legislation requires employers to have health and safety policies and arrangements that should be an integral part of their overall management policy. Within a school, there is no specific legal requirement to have a health and safety policy for each subject area although it would be good practice to do so. Where such a document for sciences exists which defines the organisation of health and safety, the procedures and routines to be followed, the delegated duties of individuals etc. it should be disseminated to all teachers and technicians. Advice on writing such policies can be found on the health and safety pages of the SSERC website [3] and Safeguards in the School Laboratory, 11th edition, ASE, 2006.

4.3 Risk assessment

It is an employer's responsibility to assess and control risk although the task of assessing risk may be delegated to employees. If such tasks are delegated to employees then it is the employer's responsibility to provide training and resources to allow them to do so and to monitor and review the risk assessments produced.

Whatever the circumstances, it is good practice for science departments to assess the risks involved in their practical work as part of their general management of health and safety. Where health and safety policies and risk assessments are produced by a science department, they should be copied to the employer (in practice, in most cases, the Head Teacher).

Risk assessment need not involve writing down every hazard associated with every process carried out in science and assessing its risk (although some employers may require this). Risk assessment is usually carried out by consulting model (or general or generic) risk assessments and considering how they should be applied. This may involve adopting the model risk assessment or adapting it to meet the particular circumstances in the school. Therefore risk assessment is a thinking process involving a comparison between a model risk assessment and, say, the particular circumstances of the class to be taught and the room to be used. Suitable sources of model risk assessments are listed below.

Such risk assessments must be recorded and communicated to other members of the department and technicians. Evidence should exist that model risk assessments have actually been consulted, adopted or adapted and implemented. This could be done through policy statements in a departmental handbook and reference

to specific model risk assessments (with any adaptations) for specific activities in the teachers' guide to student learning activities A good way to decide on the adoption or adaptation of model risk assessments is to apply the *Five Steps to Risk Assessing* [4] devised by the Health and Safety Executive (HSE) using the SSERC *Risk Assessment 5 Step Template* [5]. Where model risk assessments cannot be found for any particular activity then the employer's guidance on assessing risk should be followed or use should be made of the advice on assessing risk on the SSERC website. Strategies for managing Health and Safety risks are listed in Appendix 5.

Suitable sources of model risk assessments
• Health and Safety pages of the SSERC website http://www.sserc.org.uk/index.php/health-a-safety.
• Safeguards in the School Laboratory, 11th Edition, ASE 2006.
• Topics in Safety, 3rd Edition. ASE, 2001 (currently being revised, completed chapters available from ASE website http://www.ase.org.uk/resources/health-and-safety-resources/revised-topics-in-safety/).

Essential safety references
• Five Steps to Risk Assessing, INDG163, HSE.
• Risk Assessment 5 Step Template, SSERC.

FIVE STEPS TO RISK ASSESSMENT

LOOK FOR THE HAZARDS

DECIDE WHO MIGHT BE HARMED AND HOW

EVALUATE THE RISKS AND DECIDE WHETHER THE EXISTING PRECAUTIONS ARE ADEQUATE OR WHETHER MORE SHOULD BE DONE

RECORD YOUR FINDINGS

REVIEW YOUR ASSESSMENT AND REVISE IT IF NECESSARY
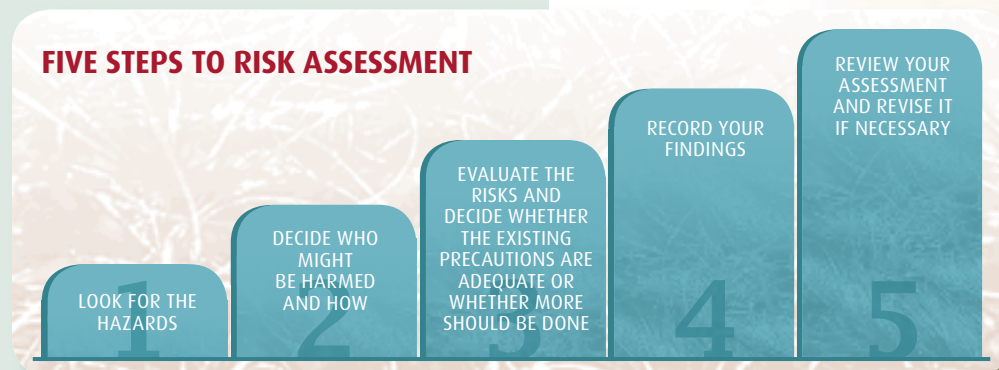
[4] http://www.hse.gov.uk/pubns/indg163.pdf
[5] http://www.sserc.org.uk/images/legacy/Risk _ Assessment/5 _ step _ template.doc

5

"Self evaluation has become increasingly embedded across Scottish education and has contributed well to improving performance and raising attainment and achievement for all learners."

Graham Donaldson, HMSCI

Self Evaluation

A good deal of activity on self evaluation focuses on carrying out quality audits, analysing performance data and reporting on standards and quality. This measuring and reporting approach provides information that is often used to make comparisons with expected standards or to other schools or departments. Although this gives an indication about how you are doing, it does not identify specific areas that need to be improved.

At a departmental level, self evaluation should focus on what students are learning so that teaching can be modified and developed to improve learning. This does not mean that current quality systems are ineffective; it is a question of using these systems to provide evidence that can be used to improve teaching. To be told that assessment performance is poor compared to others or that performance against a quality indicator is weak does not of itself help you to improve. The key then for any department is to find detailed evidence of what students are actually learning and to use that to develop an improvement agenda.

The key to improving learning is through teaching. So although the main focus of self evaluation should be on what pupils are learning, the quality of the teaching process should also be monitored.

5.1 Using assessment data to identify successful learning and gaps in learning

Traditionally, assessment data has been used to provide marks and/or grades as a measure of progress for learners, their parents and teachers. However marks and grades only provide a measure of performance against an overall standard. They do not give any indication of what has been learned. Increasingly, information drawn from both summative and formative assessment is being used to identify successes and gaps in learning.

The Unit Assessment Support Packs for National Qualifications all contain an assessment grid which shows the key areas and the types of problem solving tested by each question item and the number of marks allocated to it. Entering a learner's score against each of these then gives a ready measure of success in learning or otherwise.

There is no reason why learners cannot carry out this task for themselves or it could be done by a classroom assistant. Learners can then receive direct feedback on their own learning and areas that require improvement. Teachers can also get an overview of the learning successes and development needs of the class as a whole.

A similar process can be carried out for school preliminary exams. It is good practice to develop a grid for a prelim showing which question items test which skills and key areas of each unit of the course. As well as being used to provide feedback on successful learning or otherwise to learners, this information can be submitted along with the prelim question paper and mark scheme as supporting evidence for the consideration of exceptional circumstances.

Every year, the Principal Assessors for national examinations publish an External Assessment Report on the SQA website.

This report provides information on candidates' performance and identifies strengths and weaknesses in learning at a national level.

Other more informal methods of assessment include formative assessment, not least of which is teacher questioning. This will also provide information on successful learning and gaps in learning. There is much to commend feedback strategies such as 'two stars and a wish' and 'traffic lights' to identify strengths and weakness instead of, or as well as, mark scores.

In any event it is good practice, once this kind of assessment data is collected, to use it as the basis of discussion at departmental meetings. The science team can then identify curriculum areas where teaching strategies need to be strengthened or developed. In this way, a review calendar for learning progress can be drawn up starting with SQA External Assessment Reports in August/September, go on through Unit assessment and prelims and include other formative assessment information, including homework, along the way. An outline annual calendar for the review of assessment data is given in Appendix 6.

The more challenging part, of course, is then to come up with the teaching strategies to bridge any gaps in learning that have been found! This is probably best done collaboratively, with the department working together or more widely with others and sharing ideas about effective teaching strategies.

> *"What gets measured gets managed."*
>
> *Peter Drucker*

5.2 Using assessment data to monitor departmental progress

If assessment data is being used to identify gaps in learning, and these are then addressed by strengthening and developing teaching, then hopefully the quality of learning will improve. This is where the widely available analysis of school performance data such as Insight (formerly Senior Phase Benchmarking Tool) that has replaced STACS (Standard Tables and Charts) can be useful; not in comparing yourself to others or arbitrary standards but to your previous performance. Measuring progress in relation to action taken is a sound strategy for providing evidence of improvement. Teachers and departments can also collect their own data to monitor departmental progress. Centrally held records of class homework and continuous assessment are valuable in this regard. This allows a teacher or principal teacher to scan this information with ease and readily identify pupils who may be encountering difficulty. Systems for doing this can range from paper systems with charts in a loose-leaf folder to spreadsheets with embedded formulae to highlight scores using traffic lights to identify strengths and weaknesses.

Many science departments are concerned about pupil uptake of science subjects. One way of monitoring this is by what is known as the 'science factor'. This is calculated by adding the total number of candidates taking Biology, Chemistry, Physics and Science courses in any one year in the senior phase and then dividing the total by the number of learners in the cohort. Obviously if everyone is taking at least one science subject the science factor figure should be at least one. Previous calculations with Standard Grade over a range of schools have shown an average science factor figure of 1.27. By monitoring the science factor over time patterns of uptake of science can be followed.

Further information on evidence-based education research and action research in education can be found in the leadership pages of the SSERC website.

5.3 Quality check on school prelims

School prelims can be used to make estimates and may be submitted as evidence in cases of exceptional circumstances. They should provide similar evidence to that of the final exam. A prelim also gives learners experience of the final examination conditions. There are three quality checks that can be carried out on prelims: a check on the paper as a whole, a check on the individual question items and a concordance check of the estimated results against the actual results.

The prelim should cover the units of the course proportionately. All the skills areas should be covered and the proportion of marks of knowledge and understanding to skills should follow the guidance in the Course Assessment Specification. In addition, around 30% of the total marks should match the grade description in the Course Assessment Specification for 'A' type questions. In this way a candidate cannot achieve an 'A' grade without scoring in 'A' type questions yet a 'C' candidate can still get sufficient marks for a pass from the remainder of the paper.

Compiling a prelim paper to match the exam specification can be a challenge. Although some schools choose to write completely new questions to exam standard, many choose to select questions from a range of past papers and modify them slightly to create a prelim. When compiling a prelim paper, it is good practice to construct a grid showing for each question item:
• which unit of the course it covers
• if it is a KU or skills item
• if it is a skills item, which type of skill it is
• if it is an 'A' or 'C' question according to the grade descriptions in the Course Assessment Specification or a 'B' question by judgement.

This completed grid for the prelim should be retained and may be submitted with the prelim question paper and mark scheme as evidence in the event of exceptional circumstances.

Individual question items should be checked to ensure that the science is correct and within the scope of the Course Assessment Specification. The mark scheme should be similarly checked to ensure the science is also correct and to be found within the Course Assessment Specification. It is good practice to review the mark scheme after the prelim and, in light of candidates' responses, make any necessary adjustments. Similarly questions can be reviewed after the prelim and adjusted if necessary for future use. This is similar to the SQA quality processes that take place during markers' meetings, question item checking and pre-testing. You should also carry out marker check procedures, such as cross marking with colleagues to ensure a common standard or at least until you can be confident that marking is consistent.

A concordance check of a prelim can be carried out by ranking candidates in order of their prelim marks and then entering their actual examination grades beside them once known. The correlation between the two will give you an indication of how close your prelim was to the actual examination (concordance). This will also help to gauge your accuracy in setting cut off scores for A, B and C grades in the prelim.

5.4 Self evaluation of learning and teaching

Learning is most effective when the teacher employs a variety of teaching methods. Although a range of different approaches can enhance learner interest and motivation, a learning activity should be selected to ensure the most effective means of achieving a particular course objective or lesson outcome.

The teacher should actively engage with learners giving clear expositions and explanations and questioning them to check and develop their understanding of key ideas. The value of a good humoured, positive, atmosphere of mutual respect where learners work willingly to good effect should not be underestimated. Learning activities are most effective when learners are actively engaged in practical work or in the related development of problem solving skills that require them to think and make decisions. In evaluating the quality of learning and teaching there are three main areas that need to be addressed: the teaching process, students' learning experiences and meeting learners' needs.

5.4.1 Quality of the teaching process
Effective science lessons tend to have a number of characteristic features. Teachers are well prepared for lessons and are clear about what they are going to teach and have thought carefully about the approaches they are going to use. They share this information with their learners so that they, in turn, are clear about what is expected of them. Resources for the lesson are appropriate, sufficient, well organised and to hand.

During the lesson a good pace of learning is maintained, learners are purposefully engaged on task, safe practice is being observed and learners understand what they are doing. Prior learning is taken into account and learning is consolidated at the end of the lesson. Suitable homework is set which reinforces the learning of key knowledge or skills.

Evaluating the teaching process is best done by peer observation with a fellow subject specialist. Although a checklist is provided in Appendix 7, using this to grade or score a lesson would not be particularly helpful. A professional discussion between two subject colleagues where both offer comments about what went well and what might be improved around the points in the checklist will be much more useful. In this way the purpose of the observation becomes an improvement rather than a monitoring agenda. Observation for improvement and observation for monitoring should be kept separate. Monitoring is best reserved for where a teacher is having particular difficulties with the teaching process.

Understandably teachers can be apprehensive about being observed. The outcome of such observations should be helpful and supportive rather than judgemental. Formal feedback on strengths, areas for development and next steps can be avoided by the observed teacher taking the lead in the discussion with the observing teacher responding to the comments made. This can be aided by teachers within the department agreeing among themselves who will observe whom and by the principal

teacher joining in that process as an equal. Consideration could be given to keeping an agreed record of such observations for evidence should a HMI inspection take place! More importantly, the record provides useful information of good practice. This can be shared and discussed at departmental and science team meetings.

5.4.2 Quality of learning experiences
Learning experiences in science encompass the acquisition of knowledge and understanding, the development of skills and practical laboratory work. In all of these areas learners should have the opportunity to think for themselves and take responsibility for their own learning. In addition learning experiences should engage learners actively in collaborative activities that require teamwork and co-operation. Above all learning experiences should be stimulating and motivating. As a result learners should be motivated and actively involved as effective contributors in their own (and others') learning and development.

The evaluation of learning experiences is best done collaboratively across a science department or perhaps by a small working group within it, rather than by direct classroom observation. The checklists in Appendices 8, 9 and 10 can be used to ensure that learning and teaching programmes have a suitable range and variety of approaches, cover all the thinking and problem solving skills and types and purposes of practical work. A useful starting point for evaluation could be to use each of the checklists to audit existing course materials. Further information on the quality assurance of science curriculum provision can be found in the leadership pages of the SSERC website.

5.4.3 Quality of meeting learning needs
Meeting learning needs is about making provision for learners of different abilities through differentiation of tasks, activities and resources. This can be challenging, particularly if there is a wide range of abilities in a class. Support and challenge should be provided for all learners, not just the most vulnerable, to maximise their progress. This can be tackled in a variety of ways.

In courses for National Qualifications there is little to be gained by learners embarking on courses to which they are unsuited and unlikely to achieve success. Much work has been done in recent years in correlating previous experience and success with likely future attainment based on monitoring and tracking information on learners' progress. Use should be made of such information, especially when seeking to place learners in courses appropriate to their needs and aspirations.

In the Broad General Education, in particular, it should be recognised that learners mature and develop at different rates. They respond differently to different subjects, teaching approaches and learning styles. All of this supports having classes with a mixture of abilities or, where setting is used, at least ensuring that movement between sets or groups is possible - so that no artificial barriers to learning are created.

Science has a long history of attempting to meet learners' needs through differentiation of course materials. Some systematic approaches involving graded worksheets and resource based approaches were not successful. The teacher sometimes spent substantial amounts of time in the management of worksheets, often at the expense of interacting with learners. Such approaches can result in learners not being sufficiently challenged by tasks that are routine. The pace of learning slows as they work through the resources rather than being led by the teacher. Alternative pieces of work that develop strengths and overcome difficulties are, of course, desirable.

However, it is the teacher who should be identifying where such support is required and determining the pace of learning, not a resource.

Differentiation can also be achieved by flexible planning that allows for learners to achieve different outcomes from one activity. For example in a practical science lesson, learners may succeed in following a protocol, recording and presenting results appropriately, drawing conclusions and/or critically evaluating the experimental method. The achievement of some or all of these is differentiation by outcome. This approach can be easier to manage than attempting to provide a range of different tasks. It can also make more outcomes accessible to the learner, helping to avoid barriers to learning.

Differentiation and meeting learning needs are more about knowing your learners well than having a systems approach. This makes self evaluation difficult. However, there are indicators that you can look for that are related to building up a picture of your learners' abilities and aptitudes so that you can better support their learning. A checklist of indicators for evaluating learners' needs is provided in Appendix 11.

Sharing classes between teachers may be undesirable for a number of reasons, not least of which is it will take longer to get to know your learners well.

Teachers should take account of and build on learners' prior knowledge and attainment, particularly at times of transition. Learners quickly become bored and frustrated when they are required to repeat work they already understand or go through a series of exercises related to a concept with which they already have no difficulty. Identification of prior knowledge and its revision are important, but as a starting point for lessons and not as a tasks in themselves.

Information on learners' previous knowledge and attainment can be gathered from transition information from primary school, departmental central records, assessment data and by talking to previous teachers. Effective questioning of learners to check and develop their understanding is a key skill when setting tasks which challenge learners at an appropriate level. Assessment information, both formative and summative, should be fed back to learners to help them monitor their own progress. Comment only marking can provide high quality feedback that makes learners aware of their progress and what they need to do to improve. More generally, published research on known misconceptions in science [6] and SQA External Assessment Reports can provide information on difficulties that are commonly encountered by learners.

The skilful teacher can build on all of this information in allocating appropriate tasks and activities to learners or when providing support for their learning. By building on learners' prior experience, abilities and aptitudes it becomes easier to provide new learning opportunities that are suitably challenging. It also helps to maintain a good pace of learning. All of this aids the teacher to have realistic, as well as high, expectations of each of their learners.

[6] For example, Driver et al (1994), Making Sense of Secondary Science: research into childrens' ideas, Routledge, Oxford.

6

> *"Don't over plan or over manage.*
> *The sheer volume of new initiatives*
> *blunts the impact of each."*
>
> *Michael Fullan*

Improvement Planning and Development Work

A departmental improvement or development plan allows the department to take control of planning its own progress and measuring the impact of the actions it takes to improve learning and teaching. It should link with and contribute to the whole school improvement plan.

Although there are a variety of formats for improvement planning, all will have priorities, targets, tasks and success criteria. Priorities may be set for you through the school's improvement plan. That will identify the overall development needs or big issues to be addressed. In a department, priorities may arise from a self-evaluation audit or be self evident from the work of the department and performance of learners. Be wary of having too many development priorities in your improvement plan, a small number of priorities well executed are likely to have more impact on improving learning.

If development priorities are to be addressed they need to be broken down into targets (or some may prefer to call them outcomes). Targets describe what you are actually setting out to achieve. Targets should be specific, measurable, achievable, realistic and timed (SMART). To achieve targets they need to be broken down into tasks.

Tasks define the who does what and by when of the target. Each target will probably have a small number of tasks associated with it. These will be allocated to specific members of staff with a timescale for their completion and an indication of the resources allocated for the task. The statement of resources required should cover material, financial and human resources - including time.

Finally, criteria will have to be devised to evaluate success in hitting the target. These success criteria state the purpose of the target in terms of what you should see the learners (or staff) being able to do. The success criteria should make it clear why the work was being done in terms of improving learning and teaching.

The following pages show examples of departmental priorities, targets, tasks and success criteria each with an explanatory commentary.

Priority
Develop a homework programme for the Broad General Education.

This is a whole school priority brought about by a school survey which showed that the approach to homework across the school was inconsistent.

Target
To develop a homework programme for the Broad General Education that supports pupils' learning.

As a result of a departmental meeting, the science team had come to the view that much of the existing homework was there to encourage a homework habit rather than contributing meaningfully to pupils' learning.

Tasks
- Identify suitable sources of homework exercises and arrange for their purchase where appropriate.
- Identify units of course work of two to three weeks duration that are suitable for the development of homework exercises.

To be carried out by the Principal Teacher between May and June Outcome to be discussed at departmental meeting in June. Budget allocation of £200.

- Devise homework exercises of approximately one hour duration for each segment of course work that will support, reinforce and develop learning.

To be carried out by a recently qualified teacher over the whole session supported and monitored by the Principal Teacher at agreed regular intervals.

- Review assessment for learning information to identify areas that some learners find particularly challenging.
- Devise homework exercises that will support learners having such specific difficulties with their learning.

To be carried out by an experienced classroom teacher working in conjunction with the learning support teacher allocated to support science over the entire session.

Success criteria
Homework is well linked to classroom activities to support and reinforce learning. Homework exercises can be completed by most pupils in one hour and are set every two to three weeks. Alternative homework exercises are available to support pupils encountering specific difficulties.

The success criteria identify what should be achieved in terms of outcomes. As well as acting to brief those producing the materials, the criteria can be used to set a standard to evaluate the work of the group and if necessary, form the basis of a report on standards and quality or be used as part of a statement on homework policy in the staff hand book.

Priority
Further develop high quality courses for the Broad General Education.

This is a school priority identified as the school audit has revealed that many courses have been adapted from previous S1/S2 courses.

Target
To improve the quality of science practical work.

As a result of departmental discussion, the science team are concerned that practical work is not sufficiently challenging and does not contribute sufficiently to the development of science skills.

Tasks
- Audit the problem solving skills developed in existing science course practical work using appendix 7.
- Use the completed audit to identify weaknesses in skills development in current science practicals.
- As part of GTCS professional recognition, a science teacher is going to research the use of The Practical Activity Analysis Inventory, sourced from SSERC, to identify and develop practical work for a 'Science Research' elective in S3.

First two tasks above to be carried out by a small working group between August and the October break in non class contact time. No specialised resources required.

- Revise existing practical work and develop new practical work to cover all appropriate problem solving skills and state the learning outcomes for each practical.

To be carried out between October and Easter by the working group with the trialling of new practicals during prelims with technician joining the working group.

- Requisition new equipment and materials identified.

To be carried out by Principal Teacher in March/April on the basis of advice from the working group. Budget allocation of £500 identified.

- Measure current base line attainment in problem solving skills for future comparisons.

To be carried out by classroom assistant using recorded class attainment data at a suitable point in the session (to be arranged).

Success criteria
Learners' problem solving skills are systematically developed through a structured programme of practical work. Skills to be developed in each practical are identified in the pupil materials (shared learning intentions). There is a clear base line of recorded evidence of attainment in science problem solving skills against which future evidence of attainment will be compared.

The success criteria identify what should be achieved in terms of learner outcomes. As well as acting to brief the working group the success criteria can be used to evaluate the work of the group and, if necessary, form the basis of a report on standards and quality.

7

Leading Professional Learning

Developing teachers' knowledge and skills has been variously referred to as in-service training, continuing professional development (CPD) and now, most recently, professional learning. These changes in terminology reflect a concern that teacher training and development does not necessarily change teachers' classroom practice. There is a philosophy that underlines the use of the term professional learning. It is based on the definition of a learning organisation as being one where "training, learning and development are integral to the achievement of core business goals and change is recognised as a normal, ongoing process". For a school this philosophy means that teachers take control of their own professional learning, integrating it into their daily work with a focus on learners achieving improved outcomes.

7.1 Effective professional learning

There is now a significant body of research evidence on what makes teachers' professional learning effective; largely based on or derived from the pioneering work of Joyce and Showers [7]. Effectiveness is considered to be when the training or professional learning changes teachers' classroom practice and that change is sustained over time. This research has been ongoing for over 30 years and has involved the systematic review and meta-analysis of thousands of research papers on teacher training methods. The initial research focused on five different approaches to teacher training. They were:

1) **Acquiring knowledge about a theoretical approach, skill or educational initiative.**
   This can be achieved by personal reading, attending presentations or information giving sessions. Here the learning will be passive and reflective by the teacher. This approach results in teachers being better informed but has little impact on teachers' classroom practice. Research indicates that around 10% of teachers will change their practice and embed new ideas in their teaching as a result of this approach.

2) **Observing a new strategy or skill in practice.**
   This may be achieved by observing demonstration lessons or by someone modelling the new strategy with the teacher's class. This approach is passive as the delivery is one way and no teacher interaction is required. This approach results in an improved understanding of the strategy or skill to be developed and results in a further small proportion of teachers changing their classroom practice.

[7] Showers B. and Joyce B. (1996), The Evolution of Peer Coaching, Educational Leadership, 53 (6): 12-16
    Joyce B. and Showers B. (2002), Student Achievement through Staff Development (3rd edition),
    Association for Supervision and Curriculum Development (ASCD), Alexandria, USA.

3) Practising the new skill or strategy in a protected or simulated setting.
This is most often achieved in a workshop session or the teacher can select a class or group of learners with whom they would feel comfortable in trying out the new skill. Although teachers practise the use of the skill or strategy in this approach, only a further small percentage of teachers will embed the new skill in their teaching; the majority revert to their existing practice.

4) Providing feedback on the performance of the new skill or strategy.
Feedback is based on the principle of technical assistance. In most cases an 'expert' or 'experienced' teacher observes and evaluates the new practice and gives feedback on strengths, areas for development and next steps. This approach will help to embed the skill in a further percentage of teachers' practice, but overall the proportion of teachers with embedded change in their practice remains stubbornly low.

5) Creating peer coaching teams to support teachers in implementing new skills or strategies.
Peer coaching involves a team of teachers collaboratively planning and developing learning materials to achieve the goals associated with the new skills or strategies to be implemented. The teacher teams also gather data to monitor the effects the implementation has on learner achievement. This action research approach is then used to inform the team's refinement and future development of the learning approaches employed. With this approach almost all of the teachers involved embed the new skills and strategies in their practice and the learners achieve improved outcomes.

7.2 Key messages from research - making it happen

Care has to be exercised in interpreting the results of this research. Some have concluded that presentations and information giving sessions are of little value and that teachers' professional learning should be exclusively focused on creating peer coaching teams. This is not the case. The five different approaches to teacher training are not alternatives; they are parts of a sequence that lead to success. A theoretical understanding of the purpose of the new skills and strategies and the outcomes they are intended to achieve is a vital part of the process. If teachers do not know their change destination, they will embark on a journey that may take them anywhere. There is no evidence that peer coaching teams alone affect students' learning; there must also be an agenda that focuses on particular teaching skills and strategies and/or particular aspects of the curriculum. Professional learning needs to enable teachers to learn new knowledge and skills and then to transfer them into their own practice. Although information and awareness raising forms the foundation of teacher training, it is peer coaching that brings about the desired behaviour change in teachers.

What became clear from the research is that to achieve success teachers have to progress through each stage of the training model. Essentially the five steps (now modified to four as a result of the most recent research) take teachers through two processes; developing the knowledge, understanding and skills

required for change and then transferring what they have learned to change their classroom practice. Often in the past educational initiatives have failed because although teachers understood the principles of change and acquired the necessary skills they did not make the transfer to their classroom practice. In most cases this was not the fault of the teachers (although they were often blamed) it was because the training model developed the knowledge and skills required for change but did not support them in making the transfer to their classroom practice. In short it was not the educational initiative that failed it was a failure to implement the change.

Once the distinction between being prepared for change and then implementing the change by changing teachers' behaviour is understood, the role of the expert in the process becomes clear. Experts can provide the theoretical understanding underlying new skills and strategies either through face to face presentations and workshop sessions, or indirectly through teachers accessing the necessary information through personal research, or a combination of both. This is the first step in the training model. Observation of experts using the skills and strategies or observation of teachers who have mastered the skills and strategies is the second stage of the training model. Experts may also set up opportunities to practise the skills and strategies in a protected setting, the third stage of the training model. On the basis of the research findings, providing feedback on the performance of the new skill or strategy has been removed from the training model. It is peer coaching that is the critical element in successfully accomplishing the transfer of the skills and strategies into

teachers' practice. The first three steps in the training model can achieve the necessary theoretical understanding behind the new skills and strategies.

There are a number of different forms of coaching but research shows peer coaching to be the most effective in transferring training into teachers' practice. Peer coaching does not use an 'expert' coach to provide feedback, nor do members of the team at any point assume an evaluative or supervisory role. Many believe that coaching involves teachers offering advice to others following observations. This is not the case in peer coaching. In peer coaching, teachers learn from one another by:
• collaboratively defining the objectives for learning
• sharing the planning and development of lessons and materials to achieve the objectives
• observing one another's lessons
• collaborating to collect data about the impact of their practice on students' learning
• meeting regularly to discuss and plan the refinement of their teaching practices to ensure the objectives are achieved

When teachers try to give each other feedback, collaborative activity tends to disintegrate. When giving feedback teachers find it difficult to avoid evaluative, supervisory comments despite their intentions to do so. In peer coaching, teachers' observing each other is an essential part of the process. However it is the one teaching who is the 'coach' and the one observing is the 'coached'. There is no discussion of the observed lesson in the technical feedback sense; the observing teacher is there to learn from watching their colleague. Regular meetings of the peer coaching team are essential for the necessary collaboration to take place. Meetings are required not only to collaborate on defining objectives for learning and to plan and develop lessons and materials; they are also required to think together about the impact of their behaviour on students' learning. Leaders of peer coaching teams should not be experts or hold a senior promoted post - it is a partnership of equals. 'Leaders' are simply there to chair sessions and keep the agenda on track.

Once this model of professional learning is understood then teachers can take responsibility (or be supported by the science curriculum leader) to follow the sequence of stages above. Thus if the teacher becomes aware of new ideas or approaches (stage 1), they can then observe others, practise skills and seek peer coaching support on their own initiative, or with the support of the science curriculum leader, to embed changes in their professional practice.

7.3 Role of the science curriculum leader in professional learning

The role of the science curriculum leader is to create opportunities to use the training development model above that leads to improved outcomes for learners. Key to this is accessing the time and resources required for peer coaching. This may require a culture change in the nature of departmental meetings that move towards a more peer coaching team model with more time being devoted to:
• discussing the aims and purposes of learning experiences
• planning and developing lesson materials and learning strategies
• sharing experiences and reflecting on learning including those gained from peer observations and from data gathered about learning success and student achievement.

The self evaluation appendices of this booklet (Appendices 7 to 11) may be helpful to inform each of the above stages.

Self evaluation, like development work, is best carried out collaboratively. In addition to allocating departmental meeting time to professional learning activity, Science Curriculum Leaders should also negotiate with senior management for protected time for peer coaching teams to meet regularly and time for teachers to observe each other. This will require developing a well thought through programme of activity with an underlying rationale. When designing such a programme a useful structure to get ideas from is the Teacher Learning Communities (TLC) model used by a number of schools when they implemented Assessment is for Learning (AifL) which is based on a peer coaching approach. Here the initial stage was expert presentations and background reading (for science Inside the Black Box and Science Inside the Black Box are useful) followed by the development of a peer coaching model. Caution has to be exercised that you do not set up a peer coaching team without a purpose or agenda. There must be a clear purpose for the professional learning that should be shared and understood by all participants. In essence the model will only lead to success if the goals to be achieved are thought through and shared with all at the outset. The model is transferrable; the role of the Science Curriculum Leader is to identify the skills, strategies or curriculum changes that are going to be the focus of the training model.

> *"All teachers should see themselves as teacher educators and be trained in mentoring."*
>
> *Teaching Scotland's Future*

More generally, Science Curriculum Leaders will be involved in identifying the professional learning needs of teachers and technicians through the processes of improvement/development planning and teachers' and technicians' professional review and development (PRD). It is important that technicians are part of professional learning in science; they are key players in bringing about improvement and should be fully involved. Even if the Science Curriculum Leader does not have a direct role in these processes, they can influence events by using professional learning activities in science to help teachers and technicians identify their development needs that they will take to their own PRD. Similarly, by making professional learning in science part of

the school improvement/development plan, the Science Curriculum Leader should be in a position to specify the time and resources required for tasks to be completed.

Not all professional learning should necessarily be 'planned' as part of school management processes. There is much to commend attending professional learning opportunities on the basis of interest or curiosity as they can stimulate ideas for development work. It is all too easy for a department to become too inward looking and such external influences and ideas can be helpful.

Excellent opportunities for professional learning in science are provided nationally. For example, the assessment workshops offered by SQA; the one day meetings organised by the Society of Biology, Royal Society of Chemistry, and the Institute of Physics; the Association for Science Education (ASE) conference and technicians' meeting; courses and workshops offered by Universities and FE Colleges as well as SSERC's opportunities for professional learning in science. A number of these organisations are also prepared to visit schools or groups of schools on an outreach basis to share their expertise. Providing an entitlement for science teachers and technicians to attend those annual events on a rotational basis as part of the department's professional learning strategy can be a motivating influence for staff. SSERC professional learning courses range from twilight events and day courses through to residential meetings lasting up to 5 days in total (these latter courses are generally delivered over 2 parts). A number of the courses are delivered through e-learning

systems and use Glow-meet technology. SSERC's professional learning spans both primary and secondary sectors and offers events for teachers, trainee teachers and technicians. The portfolio is varied and includes:

- Courses for Probationers and newly qualified teachers.
- Subject specific courses for teachers in primary and secondary sectors.
- A range of transition courses to promote enhanced interaction between primary and secondary practitioners.
- The annual Scottish Universities Science School for student teachers.
- Health and Safety courses for student teachers, teachers and technicians.
- Design and manufacturing courses for technology teachers.
- Courses targeted at science and technology support staff (many of these courses are levelled and credit-rated by SQA within the Scottish Credit and Qualifications Framework).
- Leadership courses for Curriculum Leaders and Heads of Faculty.
- The annual SSERC Science and Technology Conference.

SSERC's calendar of professional learning can be viewed on the SSERC website (www.sserc.org.uk) and printed copies (A1 size) of the professional learning year planner are distributed annually in March and are available free on request from SSERC (sts@sserc.org.uk). Delegates at a number of SSERC's courses are eligible to receive grants to support their attendance. Teachers in Local Authority funded schools in Scotland may qualify for an ENTHUSE Award from NSLC (National Science Learning Centre) to cover registration and accommodation costs associated with the courses. Contact SSERC (sts@sserc.org.uk) to see which courses qualify for such ENTHUSE funding. SSERC are also happy to discuss bespoke courses which can be offered.

Finally, there is much to commend having a professional learning policy/strategy for a science department. Some of the considerations to be taken into account when devising such a strategy or policy are provided in Appendix 12.

8

"The manager focuses on system and structure; the leader focuses on people."

Warren Bennis

Developing a Leadership Culture

Leadership is more about the culture of the organisation than the person in charge of it. In the past effective leadership was considered to be a function of the personality characteristics of the person in charge. It was thought that good leaders used their talents to dominate followers and tell them what to do, firing them with the enthusiasm and will power they lacked or alternatively forcing their compliance. This view suggests that leaders with sufficient personality and will can triumph over whatever circumstances (and people) they are presented with. However recent studies on leadership performance have shown that effective leaders work to understand the values and opinions of their followers so that a dialogue can take place about what the team believes in and stands for and how it should act. Once that is achieved, leadership can shape what the team actually wants to do rather than enforcing compliance using sanctions and rewards.

Leaders are most effective when they support members of the group to see themselves as part of the group and to see the group's interest as their interest. Developing a group identity and purpose is the key task of an effective leader. Once that group identity and purpose is established, group members will be motivated to act in concert to achieve the aims of the group. This type of leadership has two major gains. One is that group members (the followers) require the minimum of supervision and monitoring - they know what is required and are motivated to achieve it. The group will function even if the leader is absent for a period of time. The second is that the group will often overachieve - group members display 'followership', that is they generate ideas and take actions that advance the group (and the leader's) vision. In short the group effort is greater than the sum of its parts. Once the leader has achieved this kind of group behaviour, leadership becomes almost invisible - that is when you know you have developed a leadership culture. The question is - how to achieve that leadership culture?

8.1 Leadership behaviour

In this approach to leadership there is no fixed set of personality traits that assure success; success depends on the behaviour of the leader. These leadership behaviours can be learned and they can be practised. Nor do you need to be a leader to practise these behaviours. Good followers often make good leaders. This should not be a surprise; a good follower will share a common sense of purpose with the leader; and a follower like a good leader, is a functioning member of the group.

The behaviours you need to practise are:

Active listening
A leader must understand the values and opinions of their team members (followers). Active listening gives the team member the opportunity to feel comfortable in disclosing thoughts and feelings and to interact at a deep level. Although the leader may actively listen to the team as a whole, there will be occasions where the leader will have to listen to team members individually. The leader must not express their views and opinions, recount experiences or make comment and judgement on what is being said during active listening - the point of the exercise is to find out the values and opinions of the team members.

> *"Most people do not listen with the intent to understand; they listen with the intent to reply."*
>
> Stephen Covey

When actively listening, the listener shows they are paying attention to what is being said by maintaining eye contact and using non verbal cues such as facial expressions, nodding etc. Questions are only used for clarification and kept to a minimum, allowing the person to speak. Open ended questions may be used to encourage people to speak and summarising and paraphrasing may be used by the leader to clarify and confirm the views expressed. As a rule of thumb the leader should listen for 80% of the time and talk for no more than 20% of the time (the so called 80/20 rule). A good way to develop active listening skills is to undertake counselling skills training. You do not need to become a counsellor or counsel the members of your team, but the skills you acquire will help you to explore their values and opinions.

Having a vision
A vision reflects the values and beliefs of the group and sets a clear direction and purpose for its work. It describes what the future will be like in a concrete way that is easy to visualise and remember. A vision should describe the behaviours of staff and learners and the feelings they will have - this is much more inspirational than empirical targets that have to be achieved.

> *"Vision without action is a daydream. Action without vision is a nightmare."*
>
> Japanese proverb.

You can form your personal vision by day dreaming. A vision should inspire enthusiasm, belief and commitment and challenge the team to excel and outdo themselves by having greater goals than simply getting the job done. It helps to write the vision down so that it can be regularly communicated and shared. Creating mission statements and strap-lines can be useful tools to help create a shared vision. Beware making the vision over complicated, it should describe what the future will look like for staff and learners and not be "a long awkward sentence that demonstrates management's inability to think clearly" (Scott Adams - creator of Dilbert). Once you have a vision then you can proceed to develop a strategy to achieve your goals using tools like the improvement/development planning process.

Visions achieved by day dreaming

"I have a dream that one day this nation will rise up and live up to its creed that all men are created equal."

Martin Luther King

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth."

J.F. Kennedy

Effective followership

Being a good follower is the ideal apprenticeship to becoming an effective leader. Good followers exhibit many of the behaviours of a good leader. Followers are committed to the group and seek opportunities to contribute to the work of the group. They are willing to learn, open to ideas other than their own and are good listeners. Within the team followers put forward their point of view, debate and argue but will follow an agreed consensus and present a united front outside of the team.

"To be a great leader, you must start as a great follower."

Anon

Strong teams keep their issues within the team; weak teams do not. Strong followers support the work, share the load and celebrate the performance of others. Like a good leader they think and speak of 'we' and rarely of 'I'. Good followers will do lots of things that will make them a candidate for a leadership position, but they do not campaign to replace the leader. Because they do their job well, good followers are ready to take on a leadership role within the team (or elsewhere) when an opportunity arises. Good followers act with honesty and integrity; they are critical thinkers who can be innovative and creative, think for themselves and give constructive feedback.

> *"Great things are never done by one person; they are done by a team of people."*
>
> *Steve Jobs*

8.2 Managing group behaviour

The key to managing group behaviour is to understand the process of how a group develops. Much of the research on models of group development is based on or derived from the research of Bruce Tuckman [8]. Tuckman developed a four stage model to explain group development based on his observations on the behaviour of many groups as they evolved. The model is based on the premise that all groups go through four predictable, developmental stages to become effective. The progression is: forming, storming, norming and performing.

- In the forming stage there will be gathering of information and discussion about tasks. People focus on routines, such as team organisation, who does what, when to meet etc. This is a comfortable stage to be in (a 'talking shop') but not much actually gets done. Group members are keen to be accepted by the others and to avoid controversy and conflict.

- As the team progresses to the storming stage they express differences of ideas, feelings and opinions. Decisions don't come easily. The leader may be challenged and people may vie for position and authority. Cliques and factions can form and there may be power struggles. Others may disengage and stop contributing to the group. Some will feel the group is getting to grips with the real issues, others would prefer the comfort and security of stage 1.

- In the norming stage agreement and consensus are largely formed among the team. Roles and responsibilities are clear and accepted. The team has an established way of working and discusses and develops its processes. Team members appreciate each other's skills and experience, listen to one another and accept others' views. Commitment and unity are strong. The team may engage in fun and social activities.

- Not all groups will reach the performing stage where the team knows each other well enough to be able to work together, and trusts each other enough to allow independent activity. The team has a shared vision and a high degree of autonomy. Genuine delegation of authority to the group members rather than the allocation of tasks is the norm. The team often over achieves its goals. Group identity, loyalty and morale are high and everyone is equally task and people orientated.

[8] Tuckman B. W. (1965), Developmental Sequence in Small Groups, Psychological Bulletin 63, 384-399.

To progress a group through these stages a leader has to deploy the appropriate levels of direction and support at each stage. Direction can be achieved by developing or sharing a vision, explaining a rationale, answering questions, identifying goals and targets. Support will involve active listening, explaining and justifying decisions, managing conflict and non participation. The skill is to get the balance of direction and support right at each stage to move the group forward.

At the forming stage the leader's emphasis is on giving direction. You will need to be prepared to answer lots of questions about the team's purpose, objectives, and relationships with others.

The storming stage is the most demanding for the leader as they have to provide both direction and support - you have to roll your sleeves up and do a lot of work, but the payback will come later. You may have to provide support to the group as a whole and also to individuals within it (together or on their own) to resolve issues and ensure participation. Ground rules, roles and responsibilities will have to be made clear to prevent conflict persisting. You may have to resolve conflict in all its forms with and between individuals.

Once the hard work is done and the group is at the norming stage, direction should no longer be required, although you will still be providing on-going support to develop trust and to build relationships and consensus. You should now be able to lead from within rather than the front - the true meaning of facilitation.

Image: jscreationzs/FreeDigitalPhotos.net

Once the team gets to the performing stage, both direction and support from the leader can be low. The leader identifies projects, tasks and oversees the work of the group, delegation is the norm and the team operates with a high degree of autonomy, it does not need direction or assistance from the leader. However, team members may ask the leader for support with their self development via coaching and review.

Not all groups will progress smoothly through these stages. It is common for groups to get stuck in the storming phase. The danger here is that instead of progressing to the norming stage, the group slides back to the forming stage. Although this will feel more comfortable as conflict may be less obvious as a result of avoidance and non participation; the high emphasis on discussing information and approaches results in little being achieved. Return to the forming stage can also result in a slippery slope that leads to an autocratic, domineering management style where orders are given, tasks are allocated and group members' work is evaluated in a supervisory and evaluative manner. If that is the case, then leadership has been lost and a managerial culture characterised by 'micro managing' will predominate. The solution is to get the group through the storming stage through high levels of direction and support from the leader.

Groups in the norming and performing stages may also revert to other stages. For example, feelings of insecurity may arise as result of a change of leader or due to uncertainty over the direction of new work. The role of the leader in these situations is to provide direction and/or support as appropriate to take the group back to the norming/performing stages.

Selected Bibliography

- ***The Modern Science Teacher: a guide for new and recently qualified teachers, SSERC, 2013***
  Covers many of the fundamental issues of current science education and although principally aimed at new and recently qualified science teachers, is a useful source of advice and information for teachers reflecting on their practice as well as those who support new and recently qualified science teachers.

- ***ASE/SEP CD for Heads of Science and Principal Teachers, ASE 2006***
  A mine of useful information and sample documents on leading a science department from around 100 principal teachers, heads of departments, advisers and consultants. A great source of advice, hints and tips as well as example documents from science subject leaders across the UK.

- ***Leadership pages, SSERC website, www.sserc.org.uk***
  Contains a variety of useful information and references for Science Curriculum Leaders. Includes a regularly updated bibliography of current documents and references relevant to leadership in science.

- ***Health and Safety pages, SSERC website, www.sserc.org.uk***
  Includes all SSERC's Health and Safety publications and references from SSERC Bulletins brought up to date and made easily accessible for teachers and technicians. A comprehensive mine of definitive Health and Safety information and advice. Absolutely essential for every school science department. Only available with log-in and password.

- ***Safeguards in the School Laboratory, 11th Edition, ASE 2006***
  A concise and expert account of the best safety advice available. It provides advice on the main Health and Safety issues facing a Head of Science. As well as a useful reference document it should be read cover to cover by every science teacher. Absolutely essential for every school science department.

- ***Topics in Safety, 3rd Edition, ASE 2001 (currently being revised)***
  A collection of Health and Safety reference documents that provide a level of detail and background information which enables those involved in secondary science education to understand issues before making decisions on behalf of their employer, or to provide suitable advice to influence decision making.

- ***Five Steps to Risk Assessing, INDG163, HSE, http://www.hse.gov.uk/pubns/indg163.pdf***
  A HSE leaflet that helps in the assessment of Health and Safety risks. Provides clear definitions of hazard, risk and the procedure for risk assessment.

- ***Risk Assessment 5 Step Template, SSERC website, www.sserc.org.uk***
  A useful template from SSERC to record a risk assessment based on HSE's 'Five Steps to Risk Assessment'.

Appendices

Qualities of effective leaders in secondary science

- A clear vision for the contribution their subject can make to the whole curriculum and of its benefits for learners.

- Active interest in and up to date knowledge of their subject.

- Professionally up to date with national and local developments in their subject area and in science teaching as a whole.

- Good working relationships with staff and learners with an emphasis on teamwork and having high expectations of them.

- Involving teachers, technicians and other ancillary staff fully in development tasks in order to promote ownership as well as to develop and broaden expertise.

- Providing guidance and support for staff to ensure a consistently high quality of learner experience across the department as a whole.

- A systematic and rigorous approach to self-evaluation which identifies strengths and development needs and which plans for improvement.

- Introduction of initiatives which improve learning and teaching, motivate learners and raise attainment.

Items that could be included in a science department handbook

- Visions and aims of the department.

- Staff list and responsibilities.

- Discipline policy.

- Departmental timetable.

- Location of teaching laboratories, technicians' area, staff base, storage facilities.

- Teaching resources.

- Procedures for ordering equipment, materials and reprographics for class work.

- Curriculum and courses.

- Teachers' guides.

- Health and Safety policy, guidance and responsibilities.

- Homework policy.

- Assessment, recording and tracking of progress and achievement.

- Internal assessment and external examinations.

- Reporting to parents.

- Department improvement plan.

- Department review procedures (including departmental meetings and self evaluation).

- Professional learning policy and arrangements for staff.

The four capacities of Curriculum for Excellence

Successful learners

with
- enthusiasm and motivation for learning
- determination to reach high standards of achievement
- openess to new thinking and ideas

and able to
- use literacy, communication and numeracy skills
- use technology for learning
- think creatively and independently
- learn independently and as part of a group
- make reasonal evaluations
- link and apply different kinds of learning in new situations

Confident individuals

with
- self respect
- a sense of physical, mental and emotional wellbeing
- secure values and beliefs
- ambition

and able to
- relate to others and manage themselves
- pursue a healthy and active lifestyle
- be self aware
- develop and communicate their own beliefs and view of the world
- live as independently as they can
- assess risk and take informed decisions
- achieve success in different areas of activity

TO ENABLE ALL YOUNG PEOPLE TO BECOME

Responsible citizens

with
- respect for others
- commitment to participate responsibly in political, economic social and cultural life

and able to
- develop knowledge and understanding of the world and Scotland's place in it
- understand different beliefs and cultures
- make informal choices and decisions
- evaluate enviromental, scientific and technological issues
- develop informed, ethical views of complex issues

Effective contributors

with
- an enterprising attitude
- resilience
- self-reliance

and able to
- communicate in different ways and in different settings
- work in partnership and in teams
- take the initiative and lead
- apply critical thinking in new contexts
- create and develop
- solve problems

Framework of skills for learning, life and work [9]

Literacy
This is the ability to communicate by reading, by writing, and by listening and talking.

Numeracy
This is the ability to use numbers to solve problems by counting, doing calculations, measuring, and understanding graphs and charts. This is also the ability to understand the results.

Health and wellbeing
This is the ability to take care of yourself and others, and to be responsible for your learning and welfare. It includes managing your feelings, developing a positive and active attitude to life and building relationships with others.

Employability, enterprise and citizenship
This is the ability to develop skills, understandings and personal attributes - including a positive attitude to work, to others and the world's resources.

Thinking skills
This is the ability to develop the cognitive skills of remembering and identifying, understanding, applying, analysing, evaluating, and creating.

Strategies for managing Health and Safety risks

• Replace the activity with a less hazardous one that illustrates the same learning.

• Replace a hazardous substance, material or micro-organism with a safer one that illustrates the same learning.

• Teacher demonstration or restrict activities to certain classes (e.g. S5/S6 only).

• Reduce the scale to lower the risk by, for example, using smaller volumes, lower concentrations, lower temperatures or lower voltages.

• Purchase equipment that has been engineered to reduce risk, for example, improved insulation, optical connectors, low voltage tools, thermostatic cut outs etc.

• Use fume cupboards, safety screens and guards where appropriate.

• Adopt codes of practice for specific areas of activity (e.g. micro-organisms, living things).

• Train staff and learners in Health and Safety risk management techniques.

• Adopt safety rules of conduct for learners.

• Wear protective personal equipment. This is generally the weakest, and least desirable, of control measures but is sometimes necessary.

[9] Further more detailed information on the skills that contribute to each of these areas is available from the SQA website.

APPENDIX 6

Calendar for annual review of assessment data

- Discuss SQA External Assessment reports at departmental meeting in August/September.

- Record baseline examination performance of the department from Insight (formerly Senior Phase Benchmarking Tool) information for future comparisons.

- Analyse strengths and weaknesses in Unit assessment performance at departmental meetings.

- Analyse strengths and weaknesses in prelim performance at departmental meetings.

- Discuss feedback from formative assessment strategies at departmental meetings.

- Discuss analysis of homework performance information at departmental meetings.

- Calculate 'science factor' for uptake of science subjects in May/June.

- Check prelim paper for concordance and accuracy of cut off scores against final exam results in August.

APPENDIX 7

Self evaluation of the teaching process

- Share the aims of lessons with learners.

- Take account of prior learning from previous lessons.

- Use a variety of approaches to make lessons stimulating.

- Set an appropriate pace for learning.

- Provide clear explanations and instructions.

- Use ICT to enhance learning experiences.

- Organise appropriate and sufficient resources for practical activity.

- Ensure safe practice is being observed.

- Use questioning to check learners' understanding and to develop their thinking.

- Use praise effectively to encourage and build learners' self esteem.

- Consolidate new information or skills at the end of the lesson.

- Set regular homework that is appropriate and well linked to class work.

Self evaluation of learning experiences

Learning and teaching approaches for knowledge and understanding

- Making use of artefacts, visual aids and models in teacher expositions and explanations.

- Using data projectors and interactive whiteboards to enhance presentations and teacher expositions.

- Using peer teaching and peer presentations to develop knowledge and understanding.

- Discussing current scientific issues in the media.

- Discussing the social, moral and ethical implications of scientific developments.

- Providing opportunities for further reading and research.

- Using resource based learning where it is appropriate.

Self evaluation of learning experiences

Problem solving skills

- Devising hypotheses.

- Planning and designing investigations.

- Organising and carrying out practical tasks.

- Deciding on how to record results.

- Analysing recorded data.

- Drawing conclusions from recorded data.

- Evaluating experimental designs for validity and reliability.

- Evaluating results for accuracy and errors.

- Evaluating conclusions in light of known knowledge.

- Writing scientific reports.

- Making predictions and generalisations based on evidence.

Self evaluation of learning experiences

Types and purposes of practical work

- Illustrating science concepts as an aid to understanding.

- Developing competence in practical techniques.

- Generating data for subsequent analysis.

- Testing hypotheses and drawing conclusions.

- Developing skills of experimental design.

- Developing knowledge through planned sequences of experiments.

- Developing problem solving skills such as critical thinking, planning and organising, reviewing and evaluating.

Self evaluation of meeting learning needs

- Make use of information on learners' prior knowledge and attainment.

- Make use of known misconceptions in science when designing tasks and activities.

- Provide helpful feedback on learners' work and encourage them to be involved in monitoring their own progress.

- Make use of comment only marking to provide feedback and encourage improvement.

- Match tasks and activities to the needs of individual learners.

- Make use of tasks and activities that can be differentiated by outcome.

- Ensure the pace of learning is sufficiently challenging for all learners.

- Use classroom assistants and SEN auxiliaries to provide appropriate levels of support to meet the needs of all learners.

Considerations when developing a policy or strategy for professional learning

- Identify the development needs and aspirations of teachers and technicians through PRD, improvement planning and informal discussion.

- Research opportunities for professional learning that could be made available to the science department. For example, from within the department, within the wider school, from the education authority or other local bodies such as; other council departments, the NHS, colleges/universities, industries, scientific suppliers or from national organisations.

- Draw up a calendar of professional learning opportunities based on the SSERC Year Planner of professional learning [10] and include the planned regular opportunities for professional learning such as the Society of Biology, Royal Society of Chemistry, Institute of Physics and Association for Science Education annual teachers' meetings, as well as SQA and Education Scotland events.

- Think about having departmental representation at such regular professional learning events by a rotational entitlement for attendance by science staff (including technicians).

- Think about what themes of professional learning should be included in the strategy or policy. For example, to update subject knowledge, to develop approaches to learning and teaching, or to familiarise and train in the use of particular resources and equipment (including health and safety).

- Decide if professional learning opportunities are appropriate for the entire department, some of the department or individuals with a particular interest or enthusiasm.

- Decide what action as Science Leader you will take to support and follow up the professional learning to ensure its effectiveness using the 5 (now 4) steps for effective professional learning (section 7.1).