research, which validate the ideas, but some are based on the long experience of many good teachers in the classroom (anecdotal evidence), a resource not to be ignored.

"Good Chemistry teaching requires love and understanding, both of Chemistry and the students. You cannot teach a subject well that you have not mastered yourself. But you must not only know your subject you must love it as well in order to get it over to your, often unwilling, students. ..the teacher must also love and care for those whom she/he teaches as individuals." (Childs, 1987)

Top Twelve Tips for Teaching

1. Teachers must love their subject and be continually updating themselves in it and keeping their interest fresh.
2. Teachers must love and care for their students as individuals and want the best for them.
3. Teachers must be well prepared and organised, knowing their subject thoroughly but also the best ways to present it.
4. Teachers must use assessment as a tool for learning not just for labelling and categorising students, and must encourage success with praise.
5. Teachers must know where their students are coming from and be aware of the intellectual baggage they bring into class - and devise learning strategies that deal with pupil's misunderstanding.
6. Teachers in their teaching must go from the simple to the complex, from the concrete to the abstract, and provide suitable activities and experiences that will help students grasp difficult ideas.
7. Teachers must provide students with the structure and framework for their subject that will help the novice learner to grasp the main ideas, and must scaffold their learning carefully to support them.
8. Teachers must be flexible and responsive, adapting to particular students and classroom situations, and to what is happening outside the classroom.
9. Teachers must make their subjects relevant by making sure in each lesson that they relate what is done in school to the outside world, making connections wherever possible to the real world.
10. Teachers must aim for active rather than passive learning in their classrooms, and must use a variety of ways to encourage their student's involvement in their own learning.
11. Teachers must include a variety of activities, assessments, teaching aids, teaching and learning styles in lessons to provide a varied and stimulating learning environment.
12. Teachers must build up intellectual and practical skills step by step, revisiting them frequently and giving many opportunities for students to practise them.

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Principles of effective teaching

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'Good teaching is forever being on the cutting edge of a child's competence'.
Jerome Bruner

What makes for a good lesson, for effective teaching? How do we define effective teaching? Effective teaching must mean that there is significant and meaningful learning by the students. We must always remember that because we taught the lesson well does not mean that the students will have learnt anything. Many attempts have been made to identify the principles of effective teaching at second and third level, and there is a substantial agreement between them. In this article we will look at some of these principles as identified by different bodies and their relevance for teaching mathematics and science, as well as other subjects. We must also recognize that the same or similar principles and qualities will hold for teaching at any level.

Second level teaching

In recent years there have been some interesting research and curriculum development projects which have looked at what makes an effective teacher. Two of these are given below. One is from the American Association for the Advancement of Science (AAAS), which has been running Project 2061 since 1985. This is a major project to improve literacy in science, mathematics and technology. The other is the Teaching and Learning Research Project (TLRP) in the U.K. which has been running since 1999, and is due to run until 2012. It has conducted a large number of research projects at primary and secondary level, in many aspects of teaching and learning, including one into Evidence-based Practice in Science Education (EPSE). (We will look at the findings of this project in a future R&R Guide.) The TLRP research has led to the formulation of Ten Principles for

The publications from Project 2061 (http://www.project2061.org/) and from TLRP (http://www.tlrp.org/) are available from their websites and there is much in them that will be useful to the science and mathematics teacher.

AAAS Project 2061: seven principles of effective teaching

The AAAS Project 2061 aims to improve the teaching of mathematics and science in US second level schools. They have identified seven principles of effective teaching, which also apply to the professional development of in-service teachers. (AAAS, 2002)

Effective teaching and professional development for teachers will:

- Provide a sense of purpose.
- Take account of initial ideas and skills.
- Provide experiences with relevant phenomena.
- Develop and use ideas and skills.
- Promote thinking about experiences and phenomena, knowledge and skills.
- Assess progress.
- Enhance the learning environment.

TLRP: Ten Principles of Effective Teaching and Learning

The Teaching and Learning Research Project (TLRP) in the UK has been running since 1999 and has produced many useful publications (see http://www.tlrp.org/pub/index.html).

Professor Mary James from the Institute of Education in London came up with 10 Principles of Effective Teaching and Learning based on ten years of research in the UK. Although these are related to the UK educational scene they contain much that is of universal value. They are summarised here and can be read in more detail in the TLRP publication *Principles into practice: A Teacher's guide to research evidence on teaching and learning* (TLRP, 2007).

Effective teaching and learning:

1. **Equips learners for life in the broadest sense.**
   "Learning should aim to help individuals and groups develop the intellectual, personal and social resources that will enable them to participate as active citizens and as workers able to adapt."
2. **Engages with valued forms of knowledge.**
   "Teaching and learning should engage with the big ideas, key processes, modes of discourse and narratives of subjects so that [students] understand what constitutes quality and standards in particular domains."
3. **Recognizes the importance of prior experience and learning.**
   "The EPSE [Evidence-based Practice in Science Education, see http://www.tlrp.org/proj/phase1/phase1bsept.html] has found that carefully designed tools … can quickly 'diagnose' children's understanding of key science ideas and inform what the teacher does next."
4. **Requires the teacher to scaffold learning**.
   "Scaffolding is about teachers recognising when they should intervene to help the child move to a higher level of understanding."
5. **Needs assessment to be congruent with learning.**
   "Assessment should help advance learning as well as determine whether learning has taken place."
6. **Promotes the active engagement of the learner.**
   "The most effective teachers organised open, fluid activities. … children develop a stronger sense of self-worth when they are able to talk about their learning."
7. **Fosters both individual and social processes and outcomes.**
   "Pupils who worked effectively in groups also did measurably better on individual exams than those who had other forms of teaching and learning."
8. **Recognises the significance of informal learning.**
   "..when parents engage with young children in learning activities at home, children do better later on. In fact, parents' educational and economic backgrounds are less important than whether they or not they provide enriched learning environments at home for children."
9. **Depends on teacher learning.**
   "The need for teachers to develop their knowledge and skills and initiate their own classroom-based research should be recognised and supported both by government and within schools."
10. **Demands consistent policy frameworks with support for teaching and learning as their primary focus.**
    "If effective teaching and learning are the core functions of schools .. they should be the focus of policy at school and national level."

(The quotations above are taken from the commentary on the '10 Principles' by Diane Hopkins, TLRP, 2007, 14-16.)

Good teaching at undergraduate level

There are many similarities between teaching at second level and at third level, particularly in the introductory years. The list below and in Table 1 give views of what makes a good teacher of undergraduates. There is much overlap with what makes a good and effective second-level teacher, except that at second level the job is more demanding. At second level we have less experienced learners and usually, a wider range of ability and interests. Undergraduate student populations are more selective in both ability and interest. What is interesting is the great amount of commonality in what makes a good teacher, whatever the level.

Seven principles for good practice in undergraduate education
(Chickering and Gamson, 1987)
Good practice:

- Encourages student-teacher contact.
- Encourages cooperation among students
- Encourages active learning.
- Gives prompt feedback.
- Emphasizes time on task.
- Communicates high expectations.
- Respects diverse talents and ways of learning.

Table 1 The qualities of good teachers (from A Survival Guide for New Teachers, University of Technology Sydney, 2001) http://www.clt.uts.edu.au/survival.html#anchor19638970

The characteristics of good teachers as seen by their students can be summarised under three headings as follows:

Their attitude towards students:
- they want students to learn, and master the content
- they want students to develop critical thinking skills
- they display empathy
- they encourage student feedback
- they are approachable outside classes

Personal qualities of these teachers:
- enthusiastic
- open and relaxed
- motivating
- humorous

Teaching skills and practices of good teachers:
- clear explanations
- good use of anecdotes / examples
- simple language used
- student participation encouraged
- variety of media used
- well prepared / organised classes
- student views respected
- class breaks are incorporated
- not 'know it alls'
- course notes given out
- material made relevant
- take account of students' backgrounds
- relevant and timely feedback on students' work

Learning is seen to be a challenging experience while being enjoyable and rewarding for the students involved.

Getting rid of the jargon

One problem in implementing the results of research into teaching and learning is that most teachers do not have time or access to read the publications. When they do find the time, the findings may be obscured in jargon and academic language, and it is often difficult to see how relevant this is to the teacher and the classroom. The purpose of these Research and Resource Guides from NCE-MSTL (www.nce-mstl.ie) is to try and bridge the gap for the practising teacher and to provide them with ideas and resources they can use in their classrooms.

I have spoken on the importance of the teacher many times over the past 30 years (see Childs, 1986; Childs, 2007; Childs, 2009) and many international studies have shown that the teacher is the key to educational success. See for example the McKinsey Study on Successful School Systems, Barber and Nourshed, 2007. One of the conclusions of this report, which is well worth reading, focuses on the importance of selecting people with suitable qualities to make good teachers:
"The top-performing school systems have more effective mechanisms for selecting people for teacher training than do the lower-performing systems. They recognize that a bad selection decision can result in up to 40 years of poor teaching. These mechanisms acknowledge that for a person to become an effective teacher they need to possess a certain set of characteristics that can be identified before they enter teaching: a high overall level of literacy and numeracy, strong interpersonal and communication skills, a willingness to learn, and the motivation to teach." (Barber and Nourshed, 2007, p.17)

The many lists of principles for effective/good teaching have many common elements, and I want to give you my Top Twelve Tips for Teaching. My own interest is in the teaching of chemistry and I have taught this for nearly 40 years at third level, together with significant interaction with and involvement with chemistry teachers at science level. There are probably more than 12 but this is enough to be starting with, and I have tried to avoid educational jargon in the way they are phrased. Many of them are the result of extensive