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# *Linking Learning Outcomes and Assessment of Learning of Student Science Teachers*

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*ABSTRACT:* The signing of the Bologna Agreement in 1999 has major implications for all involved in third level education throughout the world. By 2010 in the 45 countries that have signed up to the Bologna process, all modules and programmes in third level institutions will be written in terms of learning outcomes. In addition, many countries outside the Bologna process are aligning their third-level educational systems to be compatible with the Bologna process in order to facilitate description of qualifications, mutual recognition of degrees, and mobility of students. This paper covers the background to the concept of Learning Outcomes, the use of Bloom's Taxonomy to write learning outcomes, the relationship between learning outcomes and competences, and the linking of learning outcomes to both teaching and learning activities as well as to assessment. In addition, the author discusses the effects of the introduction of learning outcomes into the teacher-training programme for science teachers in his own university with particular reference to the assessment of student learning.

*KEYWORDS:* Aims, assessment, Bologna Agreement, learning outcomes, objectives.

## Introduction

In June 1999, representatives of the Ministers of Education of EU member states convened in Bologna, Italy, to formulate the Bologna Agreement leading to the setting up of a common European Higher Education Area (EHEA). The overall aim of the Bologna Process is to improve the efficiency and effectiveness of higher education in Europe. One of the main features of this process is the need to improve the traditional ways of describing qualifications and qualification structures. As a step towards achieving greater clarity in the description of qualifications, by 2010 all modules and programmes in third level institutions throughout the European Higher Education Area will be written in terms of learning outcomes. The importance of learning outcomes has been clearly stated by the Council of Europe:

> *Learning outcomes are important for recognition .....The principal question asked of the student or the graduate will therefore no longer be "what did you do to obtain your degree?" but rather "what can you do now that you have obtained your degree?" This approach is of relevance to the labour market and*

> *is certainly more flexible when taking into account issues of lifelong learning, non-traditional learning, and other forms of non-formal educational experiences (Council of Europe, 2002, p. 5).*

To date, all 27 countries of the EU and 18 other countries have signed up to the Bologna process. In addition to these 45 countries, many countries outside the Bologna process are aligning their third-level educational systems to be compatible with the Bologna process in order to facilitate description of qualifications, mutual recognition of degrees, and mobility of students.

A number of follow-up meetings were held after the meeting in Bologna to move the process of implementation forward. At the Berlin meeting in 2003, the Ministers for Education issued a communiqué on the position of the Bologna Process. They emphasised the creation of a common model for Higher Education in Europe and specified that degrees (Bachelor and Masters) would be described in terms of learning outcomes, rather than simply number of credits and number of hours of study:

> *Ministers encourage the member States to elaborate a framework of comparable and compatible qualifications for their higher education systems, which should seek to describe qualifications in terms of workload, level, learning outcomes, competences and profile. They also undertake to elaborate an overarching framework of qualifications for the European Higher Education Area* (Berlin Communiqué, 2003, p. 4).

## What Are Learning Outcomes?

The traditional way of designing modules and programmes was to start from the content of the course. Teachers decided on the content that they intended to teach, planned how to teach this content and then assessed the content. This type of approach focussed on the teacher's input and on assessment in terms of how well the students absorbed the material taught. Course descriptions referred mainly to the content of the course that would be covered in lectures. This approach to teaching has been referred to as a **teacher-centred approach**. Among the criticisms of this type of approach in the literature (Gosling & Moon, 2001) is that it can be difficult to identify precisely what the student has to be able to do in order to pass the module or programme.

International trends in education show a shift from the traditional teacher-centered approach to a student-centered approach, where the focus is not only on teaching, but also on what the students are expected to be able to do at the end of the module or programme. Hence, this approach is commonly referred to as an **outcome-based approach**. Statements called **intended learning outcomes**, commonly shortened to **learning outcomes**, are used to express what it is expected that students should be able to do at the end of the learning period.

There are various definitions of learning outcomes in the literature, but they do not differ significantly from each other. The following definition of a learning outcome, from the process of learning such as, a lecture, a module, or an entire programme, is considered a good working definition:

> *Learning outcomes are statements of what a learner is expected to know, understand, and/or be able to demonstrate after completion of a process of learning. (ECTS Users' Guide, p. 47).*

### What Is the Difference between Aims, Objectives and Learning Outcomes?

The **aim** of a module or programme is a broad general statement of teaching intention, i.e., it indicates what the teacher intends to cover in a block of learning. Aims are usually written from the teacher's point of view to indicate the general content and direction of the module. For example, the aim of a module could be "to introduce students to the basic principles of atomic structure" (Kennedy, 2007, p. 20). The **objective** of a module or programme is usually a specific statement of teaching intention, i.e., it indicates one of the specific areas that the teacher intends to cover in a block of learning. For example, one of the objectives of a module could be that "students would understand the impacts and effects of behaviours and lifestyles on both the local and global environments" (Kennedy, 2007, p. 20).

One of the problems caused by the use of objectives is that sometimes they are written in terms of teaching intentions, and, other times, they are written in terms of expected learning, i.e., there is confusion in the literature in terms of whether objectives belong to the teacher-centred approach or the outcome-based approach. The situation is nicely summarised by Moon (2002) as follows:

> *Basically the term 'objective' tends to complicate the situation, because objectives may be written in terms of teaching intention or expected learning..... This means that some descriptions are of the teaching in the module and some are of the learning..... This general lack of agreement as to the format of objectives is a complication, and justifies the abandonment of the use of the term 'objective' in the description of modules or programmes (Moon, 2002, p. xx)*

Most teachers who have worked on the development of objectives for modules or programmes have encountered the above problem. One of the great advantages of learning outcomes is that they are clear statements of what the student is expected to achieve and how he or she is expected to demonstrate that achievement.

### How Can One Write Learning Outcomes?

The work of Benjamin Bloom (1913 – 1999) was found by the staff of University College Cork to provide a useful starting point when writing learning outcomes. Bloom identified three domains of learning – cognitive, affective, and psychomotor - and within each of these domains he recognised that there was an ascending order of complexity. His work is most advanced in the cognitive domain where he drew up a classification (or taxonomy) of thinking behaviours from the simple recall of facts up to the process of analysis and evaluation. His publication *Taxonomy of Educational Objectives: Handbook 1, the Cognitive Domain* (Bloom et al., 1956) has become widely used throughout the world to assist in the preparation of curriculum and evaluation materials. The taxonomy provides a framework in which one can build upon prior learning to develop more complex levels of understanding.

In recent years, attempts have been made to revise Bloom's Taxonomy (Anderson & Krathwohl, 2001), but the original works of Bloom and his co-workers are still the most widely quoted in the literature. Bloom proposed that the cognitive or knowing domain is composed of six successive levels arranged in a hierarchy, as shown in Figure 1.


*Figure 1. The Levels in the Cognitive Domain of Bloom's Taxonomy.*

Bloom's taxonomy is frequently used for writing learning outcomes as it provides a ready-made structure and list of verbs. Bloom's original list of verbs was limited, and has been extended by various authors over the years. Whilst the list of verbs in a recent publication (Kennedy, 2007) is not exhaustive, it is hoped that the reader will find the lists in the above publication to be reasonably comprehensive.

In this short article, it is not possible to discuss the rules for writing learning outcomes, but these rules and many examples are given elsewhere (Kennedy, 2007). Some examples of module Learning Outcomes for various sections of Bloom's Taxonomy in the cognitive domain are given in Table 1. Note that each learning outcome begins with an action verb.

*Table 1*
Examples of Learning Outcomes in the Cognitive Domain.

- *Recall* genetics terminology: homozygous, heterozygous, phenotype, genotype, homologous chromosome pair, etc.
- *Identify* and consider ethical implications of scientific investigations.
- *Recognise* the forces discouraging the growth of the educational system in Ireland in the 19th century.
- *Relate* energy changes to bond breaking and formation.
- *Apply* principles of classroom management to maintain an atmosphere of learning in the classroom.
- *Debate* the economic and environmental effects of energy conversion processes.
- *Compare* the classroom practice of a newly qualified teacher with that of a teacher of 20 years teaching experience.
- Summarise the main contributions of Michael Faraday to the field of electromagnetic induction.
- Evaluate the key areas contributing to the craft knowledge of experienced teachers.

Learning outcomes may also be written in the affective and psychomotor domain and these, as well as programme learning outcomes, are covered in detail in a separate publication (Kennedy, 2007).

### Learning Outcomes and Competences

In some papers in the literature, the term "competence" is used in association with learning outcomes. It is difficult to find a precise definition for the term competence. Adam (2004) comments that "some take a narrow view and associate competence just with skills acquired by training" (p. 6). The EU Tuning project (*Tuning Educational Structures in Europe),* which was initiated in 2000 (Tuning Project, URL 6) used the term competence to represent a combination of attributes in terms of knowledge and its application, skills, responsibilities and attitudes, and an attempt was made to describe the extent to which a person is capable of performing them.

The lack of clarity or agreement in terms of defining the term competence is apparent in the ECTS Users' Guide (2005), which describes competences as *"a dynamic combination of attributes, abilities and attitudes."* The Guide goes on to state that:

> *"Fostering these competences is the object of educational programmes. Competences are formed in various course units and assessed at different stages. They may be divided into subject-area related competences (specific to a field of study) and generic competences (common to any degree course)."* (p. 45)

The confusion regarding the term competence is nicely summarised by Winterton et al. (2005) as follows:

> *There is such confusion and debate concerning the concept of "competence" that it is impossible to identify or impute a coherent theory or to arrive at a definition capable of accommodating and reconciling all the different ways that the term is used* (p. 12).

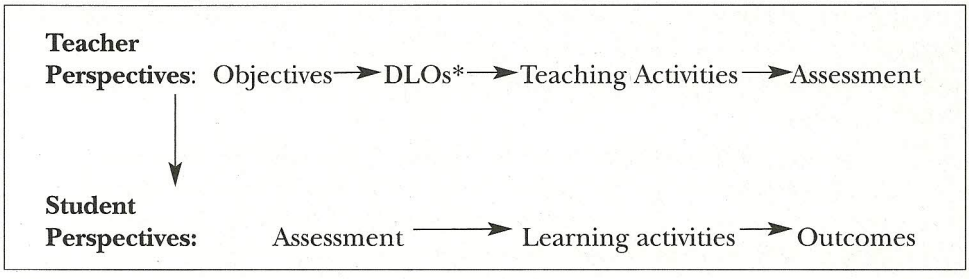
Since there does not appear to be a common understanding of the term competence in the literature, learning outcomes have become more commonly used than competences when describing what students are expected to know, understand and/or be able to demonstrate at the end of a module or programme. In essence, learning outcomes bring clarity to what has been described as the "fuzzy concept" (Boon & van der Klink, 2002) of competence.

### Linking Learning Outcomes to Teaching and Learning Activities and to Assessment

When writing learning outcomes, it is important to write them in such a way that they are capable of being assessed. Clearly, it is necessary to have some form of assessment tool or technique in order to determine the extent to which learning outcomes have been achieved. Examples of direct assessment techniques are the use of written examinations, project work, portfolios, etc. Examples of indirect assessment methods are surveys of employers, comparison with peer institutions, surveys of past graduates, retention rates, analysis of curriculum, etc.

The challenge for teachers is to ensure that there is alignment between teaching methods, assessment techniques, assessment criteria, and learning outcomes. Ramsden (2003) points out that evidence collected from student course evaluations shows that clear expectations on the part of students of what is required of them are a vitally important part of students' effective learning. Lack of clarity in this area is almost always associated with negative evaluations, learning difficulties, and poor student performance. Toohey (1999) recommends that the best way to help students understand how they must achieve learning outcomes is by clearly setting out the assessment techniques and the assessment criteria.

It is important that the assessment tasks mirror the Learning Outcomes since, as far as the students are concerned, the assessment **is** the curriculum: "From our students' point of view, assessment always defines the actual curriculum" (Ramsden, 2003, p. 280). This situation is represented graphically by Biggs (2003b, p. 3) as shown in Figure 2.




* Desired Learning Outcomes.

*Figure 2. The Difference Perspectives of Teacher and Students (Biggs 2003b)*

In stressing this point, Biggs (2003b) emphasises the strong link between the curriculum and assessment as follows:

> *To the teacher, assessment is at the end of the teaching-learning sequence of events, but to the student it is at the beginning. If the curriculum is reflected in the assessment, as indicated by the downward arrow, the teaching activities of the teacher and the learner activities of the learner are both directed towards the same goal. In preparing for the assessment, students will be learning the curriculum* (p. 3).

As already stated (Ramsden, 2003) as far as the students are concerned, the assessment **is** the curriculum. They will learn what they think will be assessed, not what may be on the curriculum or even what has been covered in lectures! The old adage that "assessment is the tail that wags the dog" is very true. Developing links between learning outcomes, teaching strategies, student activities and assessment tasks is very challenging for the teacher. Table 2 may be of help in developing these links.

*Table 2*
Linking Learning Outcomes, Teaching and Learning Activities and Assessment for Module ED 2100, ED 2104 of BSc(Ed) Programme

| **Learning outcomes** | **Teaching and Learning Activities** | **Assessment** |
|---|---|---|
| Cognitive<br>↕ Demonstrate knowledge. Comprehension Application Analysis Synthesis Evaluation | Lectures | End of module exam. |
| | Tutorials | Multiple choice tests. |
| | Discussions | Essays |
| | Laboratory work | Practical assessment. |
| | Clinical work | Fieldwork |
| Affective<br>↕ Integration of beliefs, ideas and attitudes. | Group work | Clinical practice |
| | Seminar | Presentation |
| | Peer group presentation | Project work |
| Psychomotor<br>Acquiition of physical skills. | | |

There may not be just one method of assessment to satisfy all learning outcomes and it may be necessary to choose a number of assessment methods.

The curriculum should be designed so that the teaching activities, learning activities, and assessment tasks are co-ordinated with the learning outcomes. Biggs (2003) refers to this type of process as involving **constructive alignment.** Biggs points out that in a good teaching system, the method of teaching, learning activities, and method of assessment are all co-ordinated to support student learning.

> *When there is alignment between what we want, how we teach and how we assess, teaching is likely to be much more effective than when it is not (aligned).....Traditional transmission theories of teaching ignore alignment* (p. 27)

### Introducing Learning Outcomes into Teacher-training Programmes

In 2005, learning outcomes were introduced into the teacher-training programmes for science teachers in University College Cork. A phased system of writing learning outcomes for all modules and programmes in the university is currently in operation. An example of the type of work involved for Module ED2100 of the BSc(Ed) programme in University College Cork is given in Table 3.

The level of detail shown in Table 3 is not required of staff when describing modules in the author's university, but it has been found helpful by the author to set up such a table when designing or revising modules.

*Table 3*

Linking Learning Outcomes, Teaching and Learning Activities and Assessment for Module ED2100 of Bsc(Ed) Programme

| **Learning outcomes** | **Teaching and Learning Activities** | **Assessment 10 credit module Mark = 200** |
|---|---|---|
| Cognitive<br>• Recognise and apply the basic principles of classroom management and discipline.<br>• Identify the key characteristics of high quality science teaching.<br>• Develop a comprehensive portfolio of lesson plans. | Lectures (12)<br>Tutorials (6)<br>Observation of classes (6) of experienced science teacher (mentor) | End of module exam.<br>Portfolio of lesson plans<br>**(100 marks)** |
| Affective<br>• Display a willingness to co-operate with members of teaching staff in their assigned school.<br>• Participate successfully in Peer Assisted Learning project. | Participation in mentoring feedback sessions in school (4)<br>Participation in 3 sessions of UCC Peer Assisted Learning (PAL) Programme.<br>Peer group presentation | Report from school mentor<br>End of project report.<br>**(50 marks)** |
| Psychomotor<br>• Demonstrate good classroom presentation skills<br>• Perform laboratory practical work in a safe and efficient manner. | Teaching practice 6 weeks @2 hours per week.<br>Laboratory work | Supervision of Teaching practice<br>Assessment of teaching skills<br>**(50 marks)** |

In addition to giving the detailed information shown in Table 3 to the students, each student is required to incorporate the learning outcomes for each lesson into

the planning of each lesson. In the past, students simply listed the aims and objectives. An extract showing the aims, objectives, and learning outcomes from one lesson plan is shown in Table 4.

*Table 4*
Sample Extract From a Student's Lesson Plan

**Aims:** The aim of this lesson is to introduce the concept of sound waves to the pupils.

**Objectives:** The objective of this lesson is to give pupils an understanding of how sound waves are transmitted.

**Learning Outcomes**
At the end of this lesson students should be able to:

- Recognise that a wave carries energy from one place to another.
- Identify the different parts within a wave.
- Associate the parts of a wave in a diagram to the compression and rarefraction of molecules in an actual physical wave.
- Explain why mechanical waves need a medium.
- Recognise that sound is a form of energy that causes the particles in a medium to vibrate.
- Explain how the amplitude of a sound wave determines the loudness of the sound.
- Distinguish between high frequency and low frequency sounds.

Whilst it is still too soon to draw definitive conclusions on the effect of introducing learning outcomes into the teacher-training programme at UCC, a number of key points are emerging from reports of supervisors of teaching practice supervisors, and the analysis of items, such as, student-feedback forms and students' portfolios, as well as students' teaching practice files and examination results.

The key points emerging may be summarised as follows:

- Teaching practice supervisors find an improvement in the classroom performance of the student teachers with lessons more focused on the important outcomes as outlined by the student teachers in the lesson plans.
- In their written and oral reports the teaching practice supervisors comment on the fact there is enhanced preparation apparent in the students' lesson plans with students putting a lot of effort into selecting the appropriate teaching strategies matched to the intended learning outcomes.
- Student like the clarity of the learning outcomes given to them for each module of their programme. They feel that the transparency of the learning outcomes gives them direction and help them to understand what they are expected to achieve in the module.
- Students liked the highlighting of the linking of the learning outcomes to the teaching and learning activities and to the assessment planned for them.
- In their reflective portfolios and lesson plan folders, students have frequently commented on the fact that having to write down the learning outcomes for each lesson prepared by them, helps them to focus on what they want to achieve in the lesson. This, in turn, helps them in assessing the lesson when reflecting on the lesson after they have taught it.

- Over the past three years, the examination results for the teaching practice component of the teacher training programme have shown an average increase of 8.75% across all levels for the graduating students (N = 114). Whilst at this early stage it is not possible to attribute this increase solely to the effect of introducing learning outcomes in the programme, the enhanced examination performance is certainly a step in the right direction.

The above findings are consistent with some of the advantages of Learning Outcomes as discussed in the literature by Harden (2002) and Jenkins and Unwin (2001).

## Some Concluding Points

International trends in education show a move away from the sole emphasis on a "teacher-centred" approach to a more "outcome-based" approach to education. This movement has gained increased momentum from the Bologna Process with its emphasis on student-centred learning, and the need to have more precision and clarity in the design and content of curricula. From one perspective, learning outcomes can be considered as a sort of "common currency" that assists modules and programmes to be more transparent at both local level and at an international level.

The requirement to make the teaching and learning process more transparent and more explicit presents a challenge to all of us involved in education. In the short term, those of us teaching in Europe must prepare for the immediate challenge of expressing our modules and programmes in terms of learning outcomes. In the longer term, the adoption of the learning outcomes approach has the potential to help us to embrace a more systematic approach to the design of programmes and modules.

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