



# Measuring Constructive Alignment:

An alignment metric to guide good practice

Dr Jon Tepper

*Learning and Teaching Coordinator*

*School of Science and Technology*

# Activity to get you in the mood...

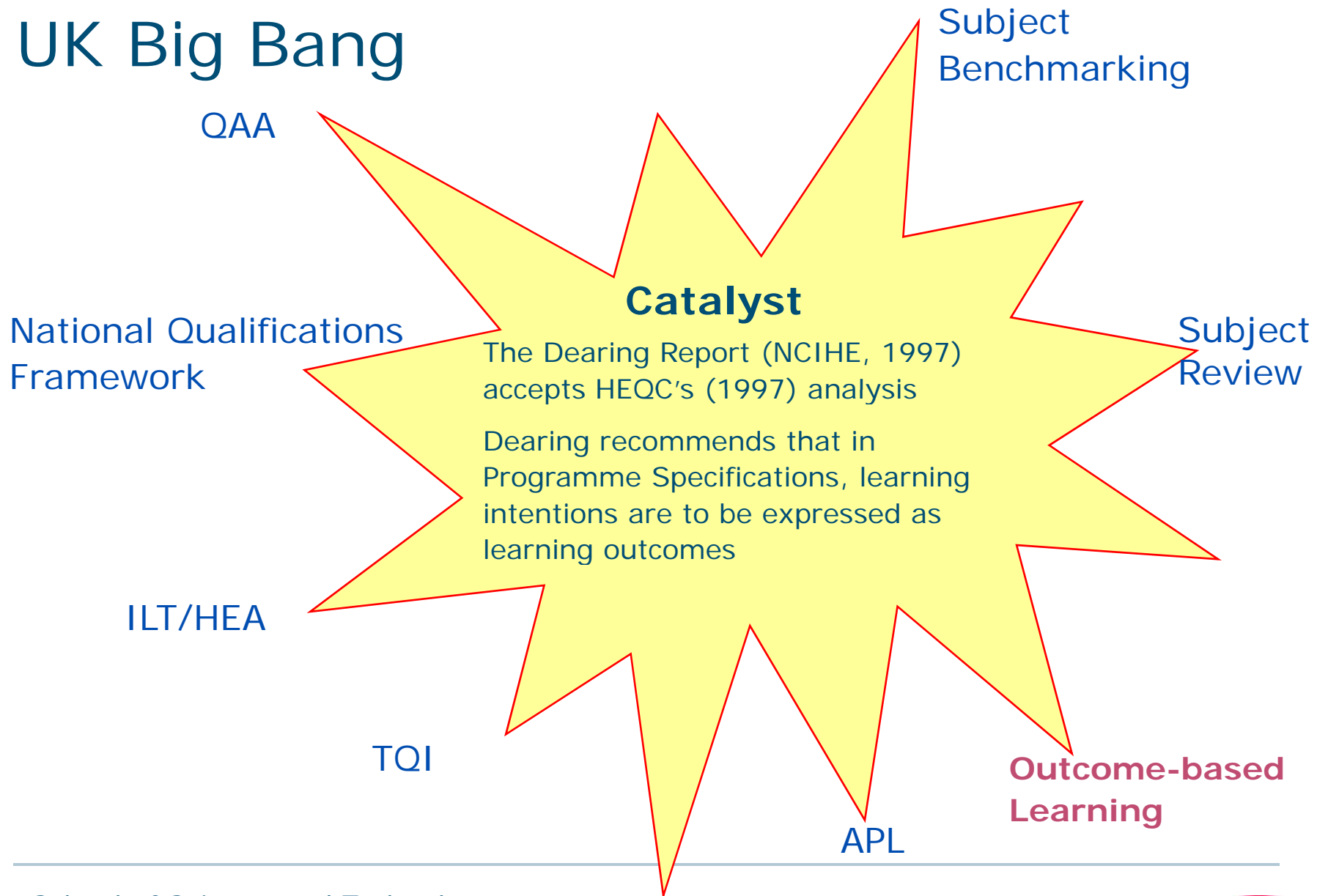
In groups of two or three:

- For each learning outcome, consider how well aligned the associated learning objectives, teaching and learning activities and the assessment tasks are;
- Identify precisely why the students and External Examiner were unhappy;
- Discuss and note down how you think the design could be improved.

# The Era of Learning Outcomes



# UK Big Bang



# International Big Bang



- Declaration signed in June 1999
- Calls for the harmonisation of HE qualification systems in Europe
- Creation of the European Higher Education Area by 2010
- Learning outcomes to play a key role

British Bologna Website

<http://www.ond.vlaanderen.be/hogeronderwijs/bologna/>

# Drivers for Outcomes-based Approach...

- QAA policy for Programme Specification encourages outcome-based learning (OBL) (QAA, 2000)
- Government's Widening Participation agenda (NCIHE 1997) gathering pace
- Student fees are here to stay (DfES, 2003)
- Emergence of TQI (HEFCE 2003)

# Implications

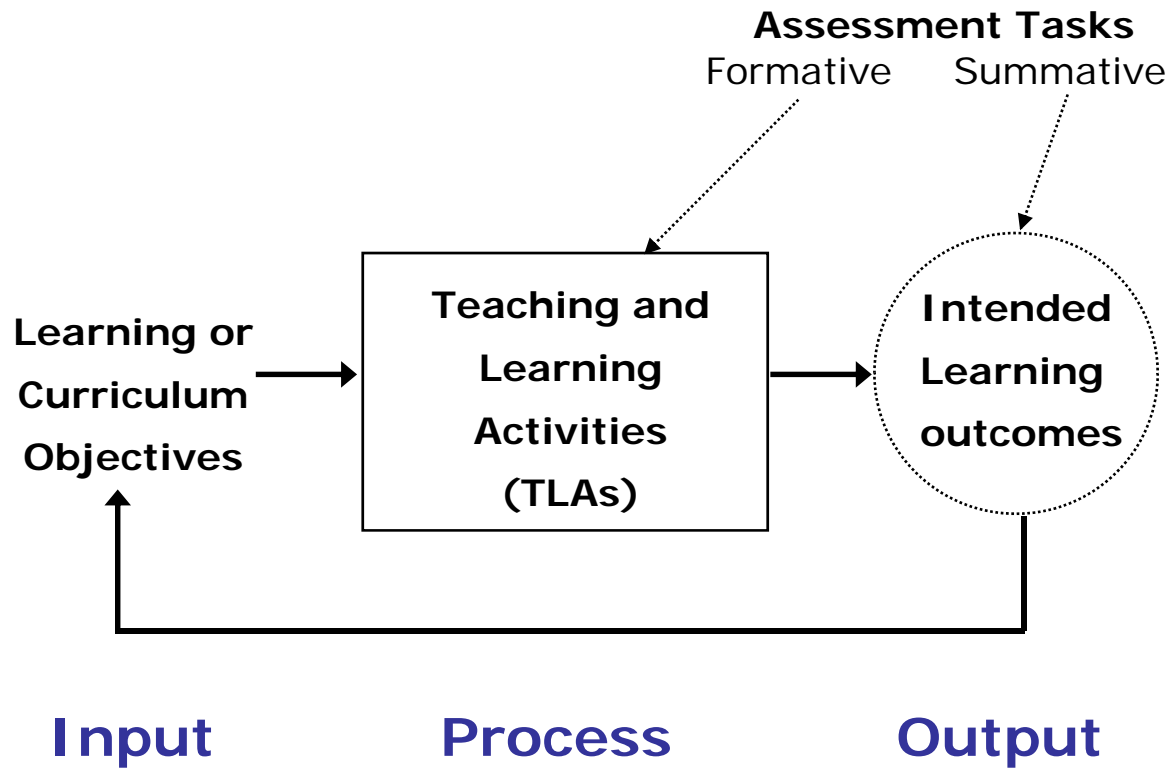
- Students (parents?) are clients and quality of programme designs will be a major selection criterion
- Widening participation = increased academic variability in student ability
  - Cannot take for granted that all learners are independent and self-motivated
- Learning and teaching strategies used should consistently ensure that **all** students accepted on course are given opportunity to meet the intended learning outcomes

# Outcome-based Educational Design



# Basic Components of a Module Design

## A Simple View



# Constructive Alignment (Biggs, 1996)

- **Outcome-based methodology** for designing, promoting and assessing deep student learning
- Fundamental assumptions are constructivist rather than instructivist
  - Students **constructs** his or her own learning through relevant learning activities
  - Teachers create a learning environment that supports learning activities **appropriate** to achieving the desired outcomes

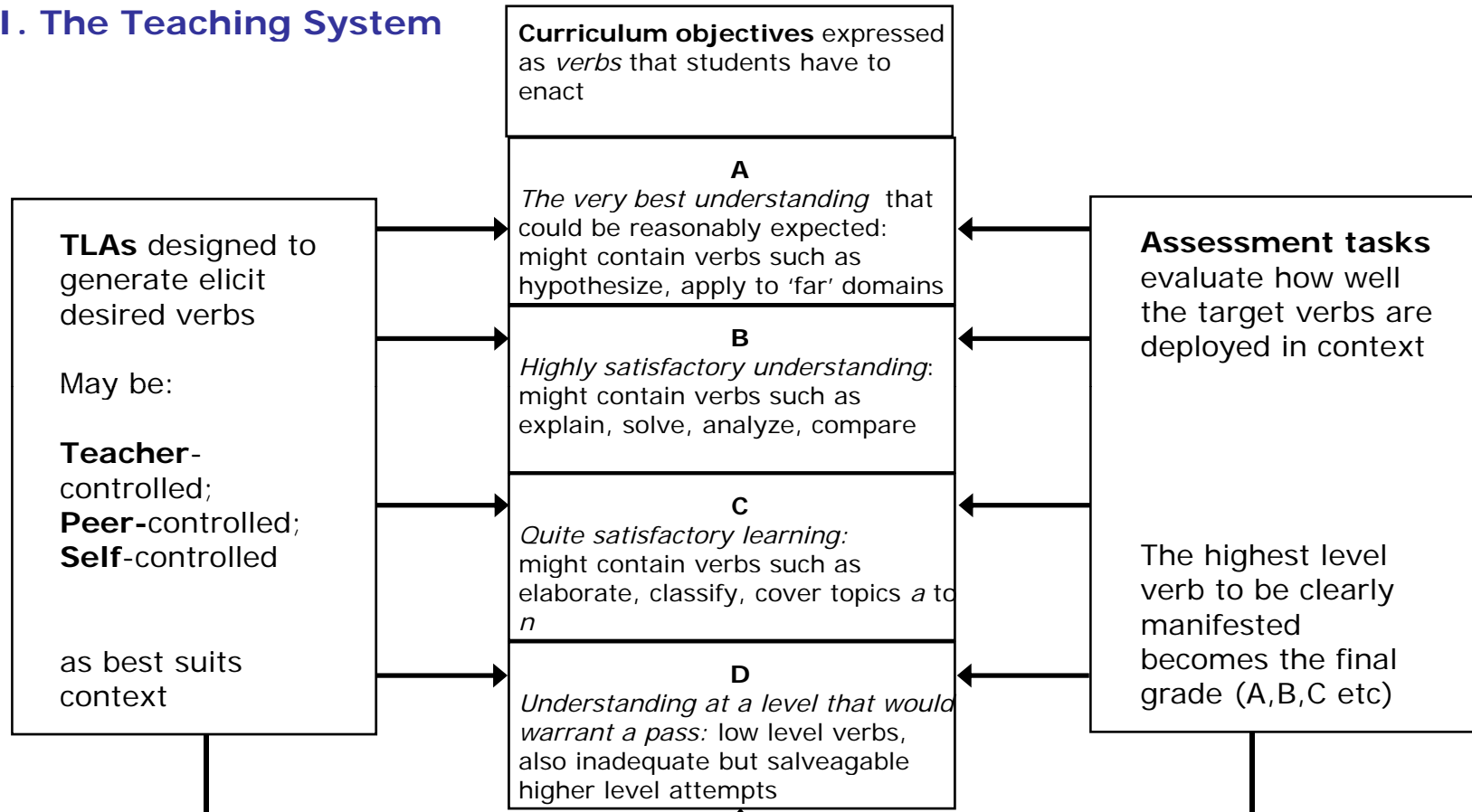
# Motivating Principle

'If students are to learn **desired outcomes** in a **reasonably effective manner**, then the teacher's fundamental task is to get students to **engage in learning activities** that are likely to result in their achieving those outcomes'  
(Shuell, 1986: 429; emphasis added)

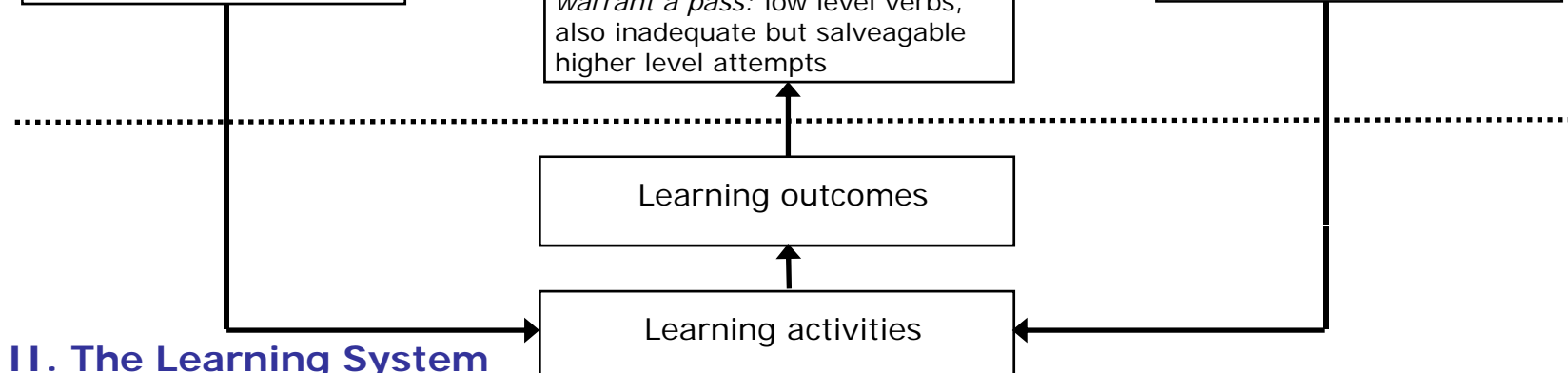
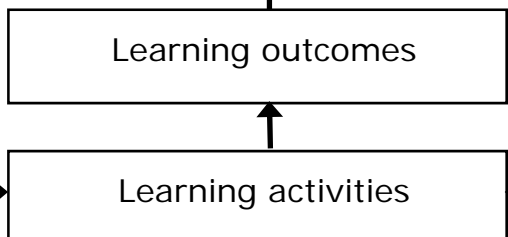
Biggs's (1996) constructive alignment facilitates us to do just that!

# Biggs's Constructive Alignment Model

## I. The Teaching System



## II. The Learning System



# Questions, questions, questions

“What do we base alignment on?”

“How do we make alignment visible and evident to all?”

“What is the student’s role?”

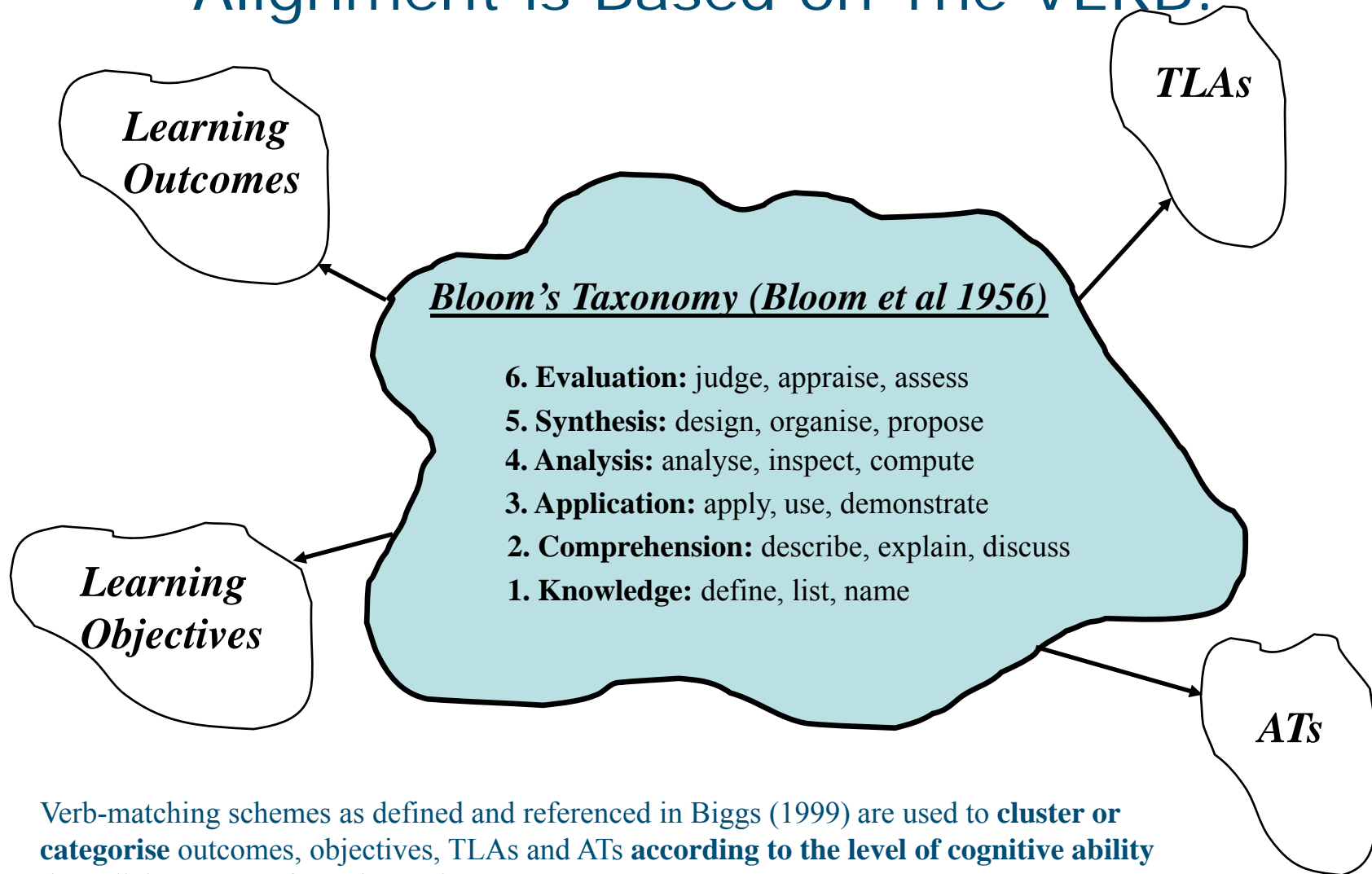
“It’s what we do already isn’t it?”

**“How can we measure alignment?  
If we can measure it,  
we can manage it  
can’t we?”**

“aligning to predefined objectives restricts development doesn’t it?”

**“Wouldn’t it be nice if there was a system that could guide practitioners to useful consistent answers”**

# Alignment is Based on The VERB!



Verb-matching schemes as defined and referenced in Biggs (1999) are used to **cluster or categorise** outcomes, objectives, TLAs and ATs **according to the level of cognitive ability** they elicit or assess from the student.

**BUT** not an exact science!

# A Metric for Constructive Alignment

## Purpose

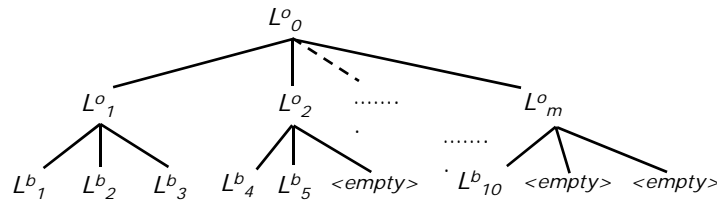
- Provide a quantitative measure of module alignment
- Facilitate teachers to adapt their practice to improve the alignment of their modules

## Premise

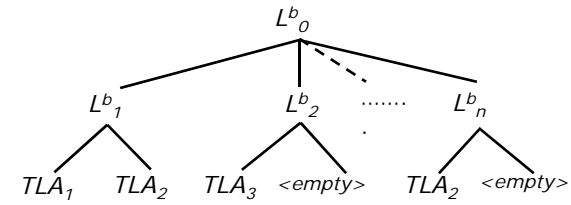
- Adopt a systemic and structural view of learning and teaching
- Categorise system components according to the level of cognitive ability they elicit from the student
- Use linear algebra to represent and compute alignment

# Generating Trees

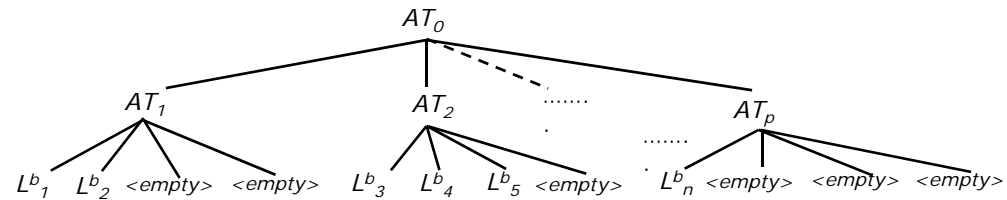
(a)  $L^o$  tree,  $c_1=3$



(b)  $L^b$  tree,  $c_2=2$

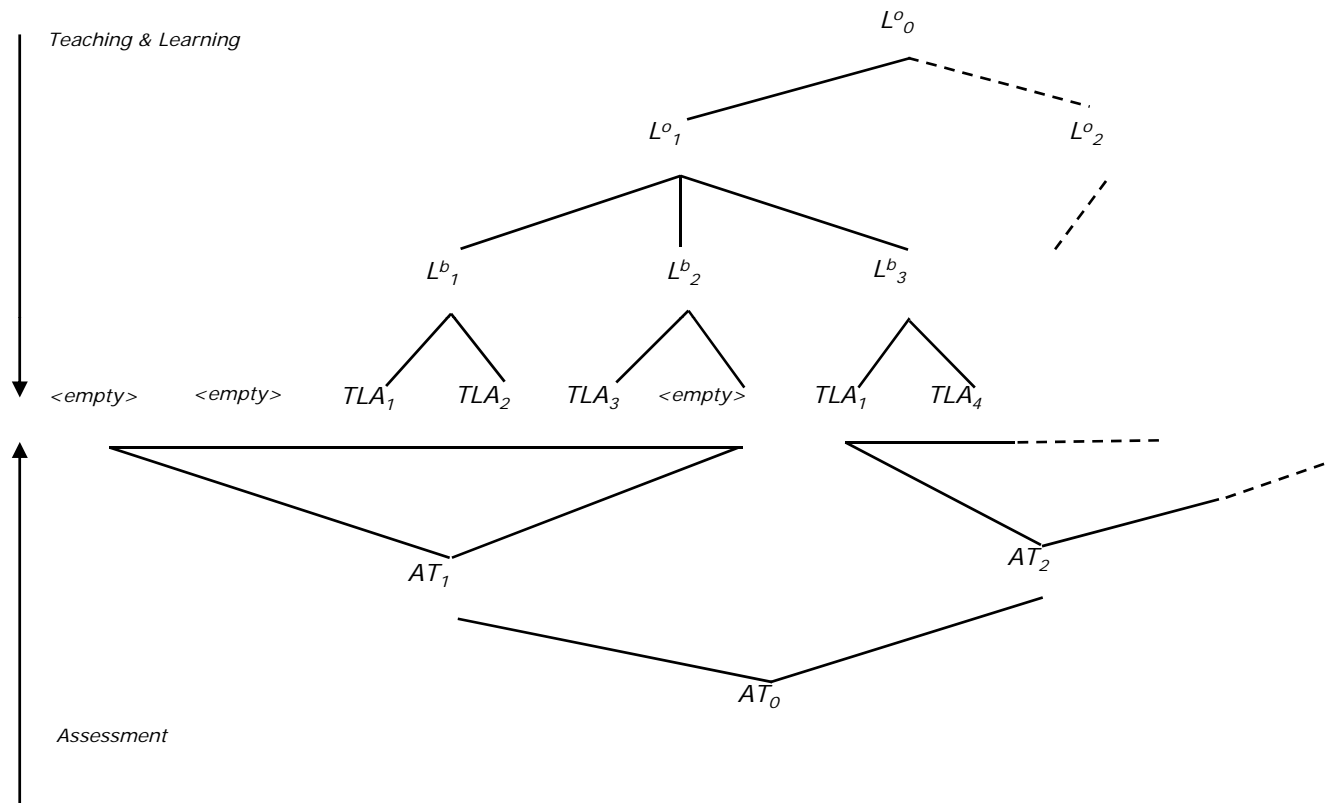


(c) AT tree,  $c_3=4$



Nodes have **dominance** and trees have **fixed valence**  
 Generate only three tree types

# Structural Perspective



# Computing Alignment

- Index each **textual definition** of an outcome, objective, TLA and AT to a level in Bloom's taxonomy
- Individually, calculate the alignment between
  - a) Learning outcomes (W) and learning objectives (X)
  - b) Learning objectives (X) and TLAs (Z)
  - c) Learning objectives (X) and ATs (Y)
- Alignment between W and Z is deduced from a) and b)
- Alignment between W and Y is deduced from a) and c)

# From Theory to Practice

- **Learning outcome #1:** Construct a context data flow diagram (DFD) given a specification (5)
  - Describe the purpose of DFDs (2)
  - Construct a context DFD for a simple system (5)
- **Learning outcome #2:** Describe the process of DFD balancing (2)
  - Explain the process of DFD levelling and balancing (2)
  - <blank>
- **Learning outcome #3:** Construct a level 1 DFD given a context diagram and high-level system description (5)
  - Define the components of a context diagram (1)
  - List the stages required to create a level 1 DFD (1)

## A Worked Example. . .

Calculate alignment between learning outcomes ( $W$ ) and learning objectives ( $X$ )

$$\mathbf{w} = \begin{bmatrix} 5 \\ 2 \\ 5 \end{bmatrix} \quad X = \begin{bmatrix} 2 & 2 & 1 \\ 5 & 2 & 1 \end{bmatrix}$$

So there are  $m$  outcomes (i.e. 3) and  $n$  objectives (i.e. 2) for each outcome. Vector  $\mathbf{x}_2$  from matrix  $X$  refers to the teacher defined objectives for outcome 2 i.e.  $\mathbf{x}_2 = [2 \ 2]^T$

$$D = \begin{bmatrix} 5 & 2 & 5 \\ 5 & 2 & 5 \end{bmatrix}$$

Where vector  $\mathbf{d1}_i$  from  $D$  is the vector of  $n$  'desired' objectives for outcome  $i$  i.e.  $\mathbf{d1}_2 = [2 \ 2]^T$

### 1. Calculate the *desired* alignment values

$$\mathbf{t1}_i = \sum_{j=1}^n \mathbf{w}_i \cdot \mathbf{d1}_{ji} \quad \text{for all } i = 1 \dots m$$

Naïve view of 'desired':  
assume that each objective elicits same level as associated outcome thus  $\mathbf{t1}_i = n * \mathbf{w}_i$

$$\mathbf{t1} = \begin{bmatrix} 50 \\ 8 \\ 50 \end{bmatrix}$$

## A Worked Example. . .

Calculate alignment between learning outcomes (W) and learning objectives (X)

2. Calculate the *actual* alignment values

$$\mathbf{u1}_i = \sum_{j=1}^n \mathbf{w}_i \mathbf{x}_{ji} \quad \text{for all } i = 1 \dots m$$

$$\mathbf{u1} = \begin{bmatrix} 35 \\ 8 \\ 10 \end{bmatrix}$$

3. Calculate the *misalignment* (error) values

$$\mathbf{e1} = \mathbf{u1} - \mathbf{t1}$$

$$\mathbf{e1} = \begin{bmatrix} 35 \\ 8 \\ 10 \end{bmatrix} - \begin{bmatrix} 50 \\ 8 \\ 50 \end{bmatrix} = \begin{bmatrix} -15 \\ 0 \\ -40 \end{bmatrix} \begin{array}{l} \text{-ve misalignment} \\ \text{perfect alignment} \\ \text{-ve misalignment} \end{array}$$

## A Worked Example. . .

*Calculate alignment between learning outcomes (W) and learning objectives (X)*

3. Calculate the *misalignment* (error) values cont'd...

```
For each learning outcome i
Do
  If  $|e_{1_i}| \leq \tau$ 
    Then If one or more  $x'_{ji} = w_i$  (for each j)
      Then the learning objectives are aligned with learning outcome i
    Else
      learning objectives are not fully aligned with learning outcome i
  Else If  $|e_{1_i}| > \tau$  AND  $e_{1_i} > 0$ 
    Then If one or more  $x'_{ji} = w_i$  (for each j)
      Then the learning objectives are positively misaligned with learning outcome i
    Else
      The learning objectives are not fully aligned with learning outcome i
  Else
    The learning objectives are negatively misaligned with learning outcome i
```

## A Worked Example. . .

*Calculate alignment between learning outcomes (W) and learning objectives (X)*

4. Calculate the *overall* alignment value for W and X

$$\begin{aligned}V_1\_equilibrium &= \sqrt{\frac{1}{m} \sum_{i=1}^m \mathbf{e}\mathbf{1}_i^2} \\&= \sqrt{0.33(-15^2 + 0^2 - 40^2)} \\&= \sqrt{0.33 * 1825} \\&= \sqrt{602.25} \\&= 24.5\end{aligned}$$

It is unlikely that an equilibrium of 0 (perfect alignment) will be achieved, however an acceptable threshold  $\tau$  should be empirically established.

*Assuming V2 (X and Z) and V3 (X and Y) equilibriums have been calculated, the alignment value for the entire module is simply:*

$$\frac{V_1\_equilibrium + V_2\_equilibrium + V_3\_equilibrium}{3}$$

# Feedback Good So Far....

- After using the model to constructively align a Level 1 undergraduate computing module, the following student feedback was received:
- Of the 47 respondents:
  - 97% agreed module was well-organised (40% strongly), an increase of 35% over the previous year
  - 94% agreed seminars were useful (30% strongly), an increase of 4%
  - 98% felt that my teaching methods and style were effective (30% strongly) a significant increase of 22%
- Constructive alignment appears to enhance the student learning experience

# But....

- Computation of alignment metric is dependent on three important factors:
  1. the ability to accurately cluster outcomes, objectives, ATs and TLAs according to the level of cognitive ability they elicit or assess;
  2. a priori definitions of acceptable prototypes of perfect or 'desired' alignment values from which to 'benchmark' against;
  3. defining realistic alignment threshold values.

# Summary

- Constructive alignment integrates instructional design with constructivist principles to produce a framework that systematically operationalises the **important characteristics** of a good teaching practitioner
- We have shown that the level of constructive alignment can be measured using vectorial representations and computations
  - to provide numerical measures of alignment for both holistic and individual aspects of an educational design
- Alignment metric is hopefully a contribution to a wider collection of metrics to measure educational phenomena
  - Educametrics?

# Summary

- Currently putting collaborative ESRC/EPSRC bid together with colleagues from Warwick, Birmingham, Aston and Bedfordshire universities to develop an intelligent software system that facilitates staff to create constructively aligned curricula
  - Development of a metric engine
  - Intelligent natural language processor to associate verbs with TLAs, ATs
  - Graphical representations of programme and module alignment (jargon free!)
  - Integration with popular VLEs
  - Potential cross-over with systems development (automatic generation of aligned system given requirement statements)

# References

- Biggs, J. (1996) Enhancing teaching through constructive alignment. *Higher Education*, **32**: 1-18.
- Biggs, J. (1999) *Teaching for Quality Learning at University*, The Society for Research into Higher Education, Buckingham: Open University Press.
- Bloom, B. (1956) *Taxonomy of Educational Objectives Handbook I: Cognitive Domain*, New York: Longman.
- Cohen, S. A. (1987) Instructional alignment: Searching for a magic bullet. *Educational Researcher*, **16(8)**: 16-20.
- Department for Education and Skills (DfES) (2003) *The Future of Higher Education: DfES White Paper*, London: HMSO.

# References

- HEFCE (2003) *Information on quality and standards in higher education: Final guidance* [WWW]  
[http://www.hefce.ac.uk/pubs/hefce/2003/03\\_51/](http://www.hefce.ac.uk/pubs/hefce/2003/03_51/) (6 January 2005), p.10.
- HEQC (1997) *Graduate Standards Programme: Final Report*, London: Higher Education Quality Council.
- National Committee of Inquiry into Higher Education (NCIHE), (1997) *The Dearing Report: Higher Education in the Learning Society*, London: HMSO.
- QAA (2000) *Guidelines for Programme Specification*. Gloucester: Quality Assurance Agency for Higher Education
- Shuell, T. J. (1986) Cognitive conceptions of learning. *Review of Educational Research*, **56**: 411-36.