Introduction

In 1996, Professor John Biggs, then at the University of Sydney, published a paper called, "Enhancing teaching through constructive alignment" (Biggs, 1996) which introduced the term, "constructive alignment" (CA) as "the marriage of two thrusts" (p. 347), namely, constructivist theories of learning, and the alignment between objectives and assessment in education. The constructivist perspective, in Bigg's view, emphasises learning in both qualitative and quantitative terms, in contrast to objectivistic theories which are "greatly concerned with quantitative measurement" (Cole, 1990, as cited in Biggs, p. 348) which "distorts the quality of teaching and learning" (Biggs, 1996 p. 348).

Bigg's concept is informed by the idea of "instructional alignment" (Cohen, 1987) which seeks alignment among the outcomes, instructional processes, and assessment. Cohen cites four studies involving alignment between instruction and assessment[1] and found that alignment benefited lower aptitude students the most, and that on a difficult task, "alignment was so effective that lower aptitude students performed better under aligned conditions that higher aptitude students under misaligned" (Cohen, 1987, p. 18) The result appears obvious, but a common theme in the literature (Cohen, 1987; Biggs, 1996) is though many teachers believe they are teaching for understanding and other high-level stated aims, they often fail not from lack of teaching skills, but from pedagogical misalignment. One explanation for this is the different perspectives of the students and the teacher: for students, the "assessment is the curriculum" (Ramsden, 1992, as cited by Biggs, 2003). In other words, students see assessment first, learning activities next, and outcomes last, in contrast to the teacher, who regards outcomes as the primary priority (Biggs, 2007).

Biggs builds on the idea of instructional alignment by combining systems theory, and the analysis of the "complex system" (Biggs, 1996, p. 350) of teacher, students, subject matter, learning activities, and outcomes, which seek a "stable equilibrium" (van Bertallanffy, 1968, as cited in Biggs, 1996, p. 350). According to Biggs, if assessment tasks address lower level cognitive activities, then "equilibrium [of the system] will be achieved at a lower level" (1996, p. 350); in other words, the actual outcomes will reflect the lowest

[1] For example, a "mis-aligned" lesson in the study focused on the conversion of Roman numerals to Arabic, then tested the student's ability to convert Arabic to Roman numerals.

cognitive level of the system, or as Biggs puts it, "a lack of alignment in the system allows students to escape with inadequate learning." (2001, p. 226).

Thus, good instructional design addresses and aligns each component of the system. Cohen recommends the creation of assessment "before designing the instructional program" (Cohen, p. 17), which is concurrent with "backwards design" model (Wiggins & McTighe, 2011). Biggs, on the other hand, preferences the design of the learning activities based on the stated outcomes (and criteria) over the design of the assessment tasks, outlining four major steps toward CA (2007):

1. Define intended learning outcomes (ILOs) as verb-predicates.
2. Design teaching/learning activities (TLAs) that address the ILO verbs and therefore likely to lead to the ILOs. [*Note: At this point, it is implied that explicit criteria for each of the ILOs has been developed]*.
3. Assess students' actual learning outcomes with assessment tasks (ATs) that are based on the ILO verbs, enabling judgement of student performance of each ILO.
4. Transform these judgements to a final grade.

For ATs, Biggs recommends a focus on the holistic match of student performances against a set of explicit criteria developed from the ILOs, in contrast to "counting marks" (Biggs, 2003, p. 4). Presenting students with clear and succinct "course objectives and grade criteria" (Biggs, 2003, p. 4) as a basis for assessment is a central tenet of constructive alignment. The strength of the explicit outcomes and criteria are twofold: 1. it discourages "backwash" strategies (Elton, 1987, as cited in Biggs, 2007, p. 169) that might result in a better grade, but not necessarily better understanding (where the student "outconned the teacher" [Biggs, 2007, p. 23]), and 2. it stipulates clear guidelines, allowing the student to immediately begin structuring and prioritising the ILOs.

Review of the TQA Physics (PHY315109) Syllabus

In order to critique the Tasmanian Qualifications Authority (TQA) physics course document (TQA, 2012) in terms of constructive alignment, I will consider some of the document's marker verbs, as well as the kind of knowledge described. Biggs differentiates between declarative knowledge (as "knowing what") and functioning knowledge (as higher-order understandings) (Biggs, 2007, p. 72). Cropley and Sitnikova expand on this idea, adding procedural knowledge (as "knowing how") and conditional knowledge (as "knowing when") (2005); functioning knowledge requires a strong foundation of declarative, procedural, and conditional knowledge.

The TQA physics Learning Statement (2012, p. 1) outlines broad statements and goals regarding scientific literacy and describes both declarative knowledge (e.g. "to engage in discourse about science"), and functional knowledge (e.g. "to describe explain, and predict natural phenomena"). The Learning Statement marker verbs are well distributed among levels of understanding (see Appendix 1) using the SOLO taxonomy (Biggs, 2007).

The Learning Outcomes (TQA, 2012, p.2) are not aligned with the Learning Statement. "Develop" is the most frequent marker verb used, and applied ambiguously, as in "develop skills", or "develop an understanding", which do not clearly identify the depth of learning expected, and are "inadequate" in a statement of outcomes (Biggs, 2007, p. 55). Although the content within the Learning Outcomes matches many of the concepts outlined in the Learning Statement, the proportion of both higher- and lower-level marker verbs (Appendix 1) do not align, thus the relationship of declarative and functional knowledge is unclear. In contrast, Biggs cites several examples (2007) of constructively aligned syllabi with explicitly differentiated outcomes which are graduated and distinct.

Alignment between the Learning Outcomes and Course Criteria (TQA, 2012, p. 12) is one of the key tenets of CA, and in the TQA physics syllabus, we again see a mis-alignment of marker verbs; whereas the Learning Outcomes focuses primarily on higher level relational knowledge, the Course Criteria has an equal mix of relational and multi-structural knowledge (Appendix 1), which is actually more aligned with the Learning Statement. Interestingly, though, the "understanding" marker verbs, which I have considered relational in the context used in the Course Criteria, are primarily contained in the externally assessed criteria (the exam). On the other hand, the content alignment between the Course Criteria and the Learning Outcomes matches well, though the latter is a largely a rephrased synopsis of the former.

The specified levels of performance of the Course Criteria are listed in the Standards (TQA, 2012, p. 13-20) and appear as rubrics. Whereas the internal assessment rubric marker verbs are well balanced in terms of levels of knowledge (Appendix 1), the external assessment rubric marker verbs lack any related to abstract knowledge (as is implicit in a timed high-stakes exam). Although Biggs is quite critical of the value of exams in assessment, considering them a surface approach and more related to "management issues" than valid, reliable, and authentic assessment (Biggs, 2007, p. 198), he does recognise their value in creating "a target for students to work toward" and "possibly for the first time, see [the unit] as a whole" (Biggs, 2007, p. 199). However, Biggs warns of the "backwash" implicit with a timed exam: though higher aptitude students will prepare with a top-down approach (creating a structure of understanding in order to prepare for the exam), lower aptitude students are prone to memorising "unconnected facts" (Biggs, 2007, p 199) which encourages surface learning.

Upon detailed review, the 2010 TQA physics exam (TQA, 2012) requires procedural and conditional knowledge in addition to declarative knowledge, and thus assesses each component of functioning knowledge. The multiple-part questions differentiate levels of understanding, but in several cases the mark was based on technical considerations rather than conceptual ones (TQA, 2012), such as correct vector representations and the number of significant figures in calculations[2]. Nearly every question challenged the student to determine the appropriate equations and calculate unknown variables, with only one question (question 17) directly assessing the understanding of conceptual theory (of quantum physics), but overall, a passing grade could be achieved by a content-driven equation-solving quantitative approach.

In contrast to the 3 hour TQA exam, which contains 18 closed book questions with multiple parts and each part largely dependent on the previous part, the Queensland Studies Authority (QSA) physics exam is a 4.5 hour exam, consisting of a closed-book 15 multiple-choice and 16 short-answer questions (each question is delineated as either knowledge or scientific processes, in alignment with the course's criteria), and 4 open book questions, out of a choice of 5. A case could be made for the greater authenticity of the QSA exam, but primarily, the QSA exam is more explicitly structured and aligned with the stated course criteria and outcomes[3], with differentiated marker verbs explicitly stated and

[2] Though these technical aspects are aligned with the "scientific literacy" of the Learning Statement, and the "communicate physics information following accepted conventions and terminology" in the Learning Outcomes, they do not appear explicitly in the Course Criteria nor the rubrics, which are more conceptual.

[3] Students are also able to take the QSA exam book home with them after the exam, encouraging further formative self-assessment.

consistently applied[4], in contrast to the TQA exam criteria, which are primarily based on the indefinite concept of "understanding".

Consideration of the weight of the TQA exam is critical to the CA analysis. Although in the Award Requirements, "ratings from external assessment will be used in addition to those provided from the school" (TQA, 2012, p. 21), the final grade requires specified exam marks, and the exam result becomes the student's grade "ceiling" (Satterthwait, 2012). In addition, the exam results are then normalised throughout the state (Satterthwait, 2012), which is a "confidence trick" (Biggs, 2001, p. 234) that makes alignment "irrelevant" (Biggs, 2007, p. 174), due to the subjugation of referenced criteria. Furthermore, "a valid or authentic assessment must be of the total performance, not just aspects of it" (Biggs, 2007, p. 184). Because of the nature and weight of the exam, therefore, the assessment is not holistically aligned with the stated outcomes of the course.

Implications for Teacher and Conclusion

With the alignment issues among the outcomes, criteria, and assessment in the TQA physics syllabus, how would a teacher best design and produce the TLAs? The teacher is provided with a broad content list of primarily equation-based physical phenomena, and has a role to assess criteria which relate to personal skills, experimental processes, and historical impacts of physics. However, the transparent weight of the exam may result in students prioritising their efforts and mental structuring toward the exam's assessment. The ability to holistically assess performance, furthermore, is further limited by the provided rubrics which are ambiguously differentiated at times[5]. The best a teacher could do in the case of the mis-aligned TQA physics syllabus would be to consider the most heavily weighted AT (the exam) as a primary outcome, and plan TLAs which address the internally assessed criteria with a focus on the conceptual knowledge that would be beneficial to solve problems typically found in the exam. Because of the mismatched outcomes, criteria, and assessment tasks in terms of both kinds of knowledge (declarative, procedural, and conditional vs. functional) and levels of knowledge (as specified by the marker verbs), the TQA physics syllabus reflects poor constructive alignment.

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[4] e.g. "information literacy, application, analysis, evaluation and synthesis skills" (QSA, 2012).

[5] For example, a 'B' student can "formulate an appropriate hypothesis to explain observations", while an 'A' student would need to "formulate an appropriate *and readily testable* hypothesis to explain observations". A properly aligned rubric, in contrast, would incorporate differentiated verbs related to levels of knowledge rather than ambiguous details of student performances.

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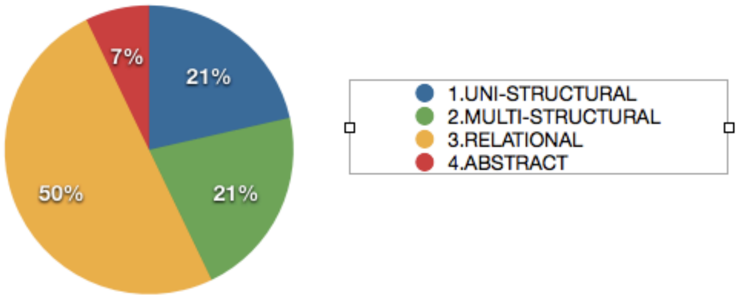
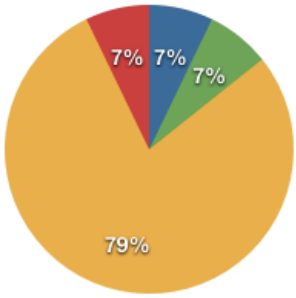
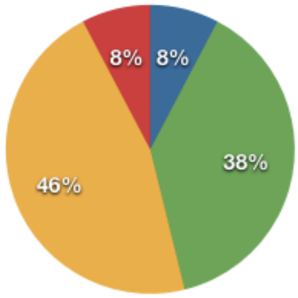
APPENDIX 1: Verb Taxonomies used in the TQA Physics Syllabus



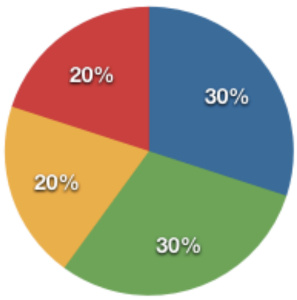
Outcomes



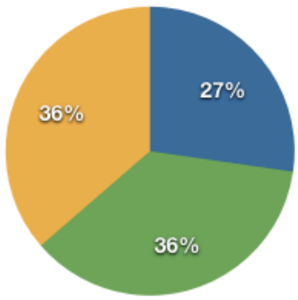
Course Criteria



Rubrics Internal Assessment



Rubrics External Assessment (Exam)



Verb Taxonomies used in the TQA Physics Syllabus

Levels of Understanding	Learning Statement	Outcomes	Course Criteria	Rubrics A internal***	Rubrics A Exam*** (per section)**
Identify	3			1	2
Demonstrate/Perform		1	1	2	1
1.UNI-STRUCTURAL	**3**	**1**	**1**	**3**	**3**
Communicate*		1	2	1	
Engage*	1				
Process*			1		
Organise activities			1		
Describe/Report/Discuss	2		1	1	1
Select				1	1
Solve					1
Recognise validity*					1
2.MULTI-STRUCTURAL	**3**	**1**	**5**	**3**	**4**
Develop*	2	7	1		
Interpret*		2	1		2
Form Opinions*	1				
Understand*	2		4		
Apply		1			1
Analyse		1			
Explain/Conclude	1			2	
Predict	1				
Contrast					1
3.RELATIONAL	**7**	**11**	**6**	**2**	**4**
Design				1	
Formulate				1	
Evaluate		1	1		
Resolve*	1				
Generalise					
4.ABSTRACT	**1**	**1**	**1**	**2**	**0**

Notes: *These verbs were not found in common taxonomies, so they were placed depending on their context in the syllabus. **The Physics Syllabus has an error in the Rubrics (the same item is listed twice for the external exam rubrics), so the equivalent verbs for the third item were added from the Physical Sciences syllabus.