Meaningful assessment: distinguishing learning outcome from product output in constructive alignment

Lesley Jolly[a]; Lydia Kavanagh[a] and Prue Howard[b].
University of Queensland[a], Central Queensland University[b] .
Corresponding Author Email: ljolly@bigpond.net.au

CONTEXT

It is easy for assessment practice to decline into the routine – doing what we have always done, or what we consider to be logistically possible – without proper attention to whether or not the assessment strategy really allows students to demonstrate their learning and matches with our learning objectives. Two decades ago Biggs (1996) drew attention to this issue in his articulation of the phrase "constructive alignment". By this he meant that courses should be designed in such a way that the desired learning outcomes are articulated with some specificity, that teaching methods align with those desired outcomes, and that assessment tasks allow students the opportunity to perform their understanding (Biggs 1999). Biggs himself noted that this was very rarely done in universities and recent studies in engineering education suggest that we do no better than other disciplines in this regard (Borrego and Cutler 2010). In consequence, we do not always have the knowledge of our students' learning that we claim to have and students struggle to know what they should be learning and how that should be done. The issue is compounded by the fact that students are assessment-orientated therefore assessment not aligned with learning objectives will seriously undermine achieving desired learning outcomes.

PURPOSE OR GOAL

In this paper we scrutinise some of the data from a large national study of the use of Engineers Without Borders (EWB) projects in first year engineering to ask what good alignment looks like and how it might be consistently achieved. EWB projects, which culminate in the submission of a group report, are typical of many project-centred and group-based assignments in current practice and our findings should have wide applicability.

APPROACH

The large study from which this paper is drawn used a broadly ethnographic approach, collecting data through documentary analysis, structured and unstructured interviews, focus groups, observations and exit surveys. The analysis was expressed in terms of the Contexts, or sociocultural conditions, that made a difference to students' ability to achieve stated outcomes and the Mechanisms, or behavioural choices, that students made in response and which affected their outcomes (Pawson and Tilley 1997). Not surprisingly the good alignment of assessment with objectives was found to have significant positive impact.

ACTUAL OR ANTICIPATED OUTCOMES

In the larger study, course controllers commonly had difficulty expressing exactly what outcomes they expected students to achieve and demonstrating how learning activities might lead to those outcomes. They also commonly had tacit expectations that some outcomes, especially the so-called generic ones such as teamwork, would just happen as a result of students working towards the submission of a group report. In fact those outcomes were best achieved where explicit attention was paid to them in teaching and assessment practices and we discuss two such strategies in this paper. One was the use of portfolio assessment which required students to be able to articulate the outcome of their learning, and the other was the use of prototype build events in addition to a group report, demonstration of individual input, and teamwork assessment.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

We conclude with a summary of how an outcomes focus can be achieved without a major redesign of the course and without departing from institutional expectations.

KEYWORDS

Learning outcomes, constructive alignment, project-based learning

Introduction

Since the mid-1990s there has been a preoccupation with outcomes-based education (OBE) around the world and in all disciplines. The Encyclopedia of Curriculum Studies defines OBE as “a student-centered, results-oriented instructional system that focuses on those processes by which each student in the school is able to demonstrate what he or she knows and is able to do to a predetermined level of attainment.” (Desmond 2010, p, 624-625). In engineering education we have seen this focus on outcomes embodied in the move to outcomes-based accreditation of university programs. In their accreditation guidelines for Australian universities, Engineers Australia (n.d.) state that “ The accreditation process does not prescribe detailed program objectives or content, but requires engineering education providers to have in place their own mechanisms for validating outcomes and continually improving quality.” Whether we use the term objectives or outcomes, the emphasis is on what students can demonstrate about what they know and can do.

Biggs’ constructive alignment framework (Biggs 1996, 1999) has been influential in how academics think about this complex problem. That framework (Figure 1, based on Biggs 1999, p. 27) is built around the need to articulate objectives in terms of levels of understanding using active and specific (not generic) verbs such as hypothesise, build, teach. Assessment then needs to be designed so as to assess those verbs – that is, if the objective is hypothesise, an exam or reflective assignment could justifiably be used to assess whether or not students can do that (depending on the question asked). On the other hand if the outcome is deemed to be a capacity to build or design, an exam is not going to be such a reliable indicator of what students know and can do in that realm. Nevertheless, many course designers fall back on standard assessment strategies without consideration of how well they test actual learning and thus focus on the product of assessment, rather than the outcome of learning. A separate but connected problem is then what kind of learning activity is going to allow students to satisfy the assessment which measures the outcomes. Although our model (Figure 1) suggests that this is a simple linear relationship, like all design problems there is much iteration in finalising design and implementation. However, it is worth noting that course designers work from objectives to learning activities while students work in the opposite direction from the learning activities to the achievement of objectives.

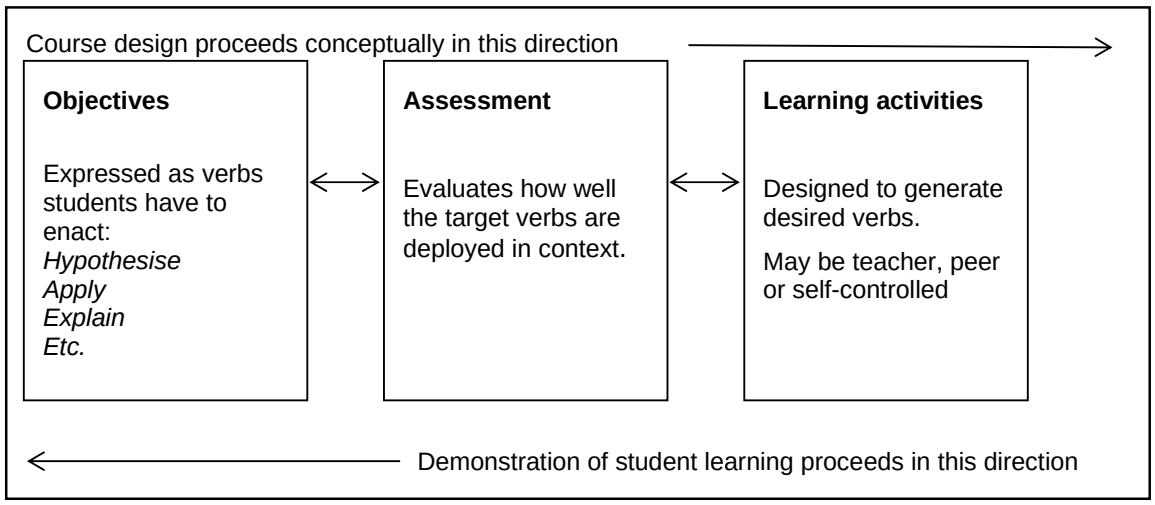


Figure 1: Constructive alignment (based on Biggs 1999, p.27)

While the principle of constructive alignment is well-accepted, its implementation is still problematic, according to our observation across a number of research and teaching projects. In this paper we will draw mainly on the findings of an ALTC/OLT project (PP10-

1647) which indicated that alignment of assessment with objectives was significant for outcomes. It emerged that objectives were not always expressed in a clear and meaningful way, and that assessment tended to focus on standard artefacts, such as group reports, without questioning whether those artefacts really demonstrated what students knew and could do.

The framework for setting objectives/outcomes and its effect on alignment

Although accreditation processes do not mandate what courses should cover or what their outcomes should be, the existence of the Stage 1 Competencies for graduating engineers sets a series of long-term goals which individual courses need to pay attention to. Since the mid-1990s this kind of list of graduate attributes for engineers has expanded to include many non-technical attainments. Figure 2 details one such set of attributes from the current list which has been influential in encouraging change in universities curricula because of the references to social and cultural settings and global operating contexts.

1.5 Knowledge of contextual factors impacting the engineering discipline.
a) Identifies and understands the interactions between engineering systems and people in the social, cultural, environmental, commercial, legal and political contexts in which they operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the engineering discipline.
b) Is aware of the founding principles of human factors relevant to the engineering discipline.
c) Is aware of the fundamentals of business and enterprise management.
d) Identifies the structure, roles and capabilities of the engineering workforce.
e) Appreciates the issues associated with international engineering practice and global operating contexts.

Figure 2: from Engineers Australia Stage 1 Competencies of a graduating engineer

The precise meaning of words such as ‘understand’, ‘be aware of’ and ‘appreciate’ would need to be clarified in order for such objectives to be useful in an assessment setting (Biggs 1999, pp.37ff.), but they do create a set of expectations about the big ideas (Wiggins and McTighe 2005) that the curriculum is expected to cover. Since 2008, one response to this demand for an inclusion of the context of engineering in the curriculum has been for universities to employ the Engineers Without Borders (EWB) Challenge as part of a first-year, team-based design focussed course. The EWB organisation draws on its ongoing involvement in development projects in countries such as India, Cambodia and Vietnam to provide an opportunity for students to address ‘real world’ problems in their contexts. The Challenge is a competition which requires student teams to come up with design solutions to locally-defined problems which pay attention to the culture, environment and economy of the site, demonstrate good project management skills and reflect on their own learning throughout the process. These outcomes have both arisen from and influenced universities’ articulation of their course objectives. However, we have noted elsewhere (Present authors 2011) that although the content and setting of the EWB projects seem ideal in some ways to address the identified outcomes, the EWB projects are neither necessary nor sufficient to doing so. It depends on what learning opportunities are provided and how validly they are assessed. Success in any teaching depends on the complete alignment of learning activity, assessment and objective or outcome. Our discussion here is therefore relevant to the design of any learning experience, although the evidence comes from a particular one.

Methodology

We draw here on a subset of the data collected in an evaluation of the use of the EWB projects in 13 universities in Australia and New Zealand funded by the ALTC which took place over 2011 and 2012. This project generated a very large and varied data set including course and policy documents, observations of classes, staff and student interviews, student workbooks and assessment pieces and a student exit survey. The data were analysed using

Nvivo software using a Realist evaluation framework (Pawson and Tilley 1997). The analysis was expressed in terms of the Contexts, or sociocultural conditions, that made a difference to students' ability to achieve stated outcomes and the Mechanisms, or behavioural choices, that students made in response and which affected their outcomes (Present authors, in press). It was not a surprise to see that good alignment of assessment and objectives was one important Context factor in whether the projects "worked" (that is attained their stated objectives) or not. In this paper we will focus on the alignment of assessment with learning goals in two cases which raise interesting issues about what is being aligned and how to achieve alignment.

Case One is a course at a regional university with around 100 students, some of whom work on campus on projects with local clients and some of whom study online and use the EWB projects. Case Two is a large cohort (around 1000 students) in a metropolitan Go8 university. There the students choose from one of four possible projects, one of which is the EWB one. The regional university uses a portfolio style of assessment in which students complete the usual range of project activities and contribute to a team report that is not graded (Eliot et. al 2012, Jorgensen and Howard 2005). Instead the student must use their portfolio of work as evidence in mounting an argument about the extent to which they have attained the course objectives. In the metropolitan university the usual range of project activities and products is augmented by a Demo Day which requires student teams to build and demonstrate a prototype of their design solution. The demonstration happens in public in front of other students, staff, industry assessors and chance passers-by.

Data from these two sites comprise course outlines, student workbooks, a total of 15 full days observation of classes, workshops, student group work and assessment events by three researchers, interviews with seven staff over two campuses, four hours of student focus groups and 400 exit surveys from the two campuses. In addition we can draw on experience of the two courses going back to 2008, related work on other projects (Eliot et al 2012) and team reflections generated in the analysis of the project data and the writing of this paper. In what follows we take some of the main themes identified in the OLT report (Present authors, in press) and in subsequent reflection as the framework for describing how these two courses worked and for generating some general principles for improving alignment.

Articulating outcomes

On the satisfactory completion of this course, the student should be able to:
1. Identify personal strengths, weaknesses and career preferences based on Engineers Australia's graduate attributes, and implement some strategies for personal professional development.
2. Undertake complex ill-defined engineering projects, including identifying and scoping problems, researching, analysing and evaluating information, and identifying, justifying and reporting appropriate solutions.
3. Investigate, develop and articulate technical knowledge required to undertake engineering projects.
4. Articulate and demonstrate effective time management skills.
5. Articulate and demonstrate effective project management skills.
6. Articulate and demonstrate effective team management skills.
7. Analyse and assess the viability of engineering projects using sustainability frameworks.
8. Present technical engineering information and demonstrate the ability to represent the engineering profession to the broader community.
9. Articulate and demonstrate personal application and development of the

Figure 3: Case 1 learning objectives, regional university, portfolio assessment.

Many authorities (Gibbs 1999, Wiggins and McTighe 2005) warn against statements of desired outcomes that either too global in reach or that fail to specify the nature of the change that is expected. The logic is that unless we know exactly what our desired outcome is, we won't be able to teach to it or assess it. The ideal is to use nouns that specify the "big ideas" that the course is about and verbs to specify what students should be able to do with those ideas (Wiggins and McTighe 2005).

Figure 3 is the list of learning objectives from Case 1. Here we see the list of so-called generic skill areas such as project management, teamwork and sustainability, which such projects are designed to address. These represent the "big ideas" that the course is about. During interviews with course controllers as part of the evaluation project it was common for academics to be able to give us such a list of nouns, but rare for people to be able to identify the specific verbs that would define the desired change in students' knowledge and behaviours that ought to be the outcome of the course. Case 1 uses an interesting range of verbs of which the most significant is probably articulate. This means students have to be able to describe what the topic, for instance "effective team management skills", means, while demonstrate requires them to show to what extent they have done that. Verbs like identify, used here, usually imply only that the student needs to be able to recite a list of factors, but in this case identification requires deep personal reflection and is followed up by the very active implement, which makes clear that the list of attributes must be acted on by the student.

Case 2 has a similarly long list of topics, some of which are expectations that are neither built into learning tasks to any great extent not directly assessed. For instance, it could be assumed that success in outcome 7 is fundamental to success in the other outcomes, since poor time management might lead to lack of completion of the work. However, since most of the assessment items were group ones, one cannot be sure that this applies to any given individual. We also see use here of the much-criticised understand, without clarifying what sort of understanding was expected and how it could be demonstrated, although some clarification was provided by the marking rubrics used. As Gibbs (1999, p.35) tells us "the challenge…is to conceive our teaching objectives in terms of students performing their understanding, rather than in getting them to declare it verbally" and it was this performance aspect that made Case 2 so successful. Although the written objective/outcome may be open to criticism, the assessment made sure that students performed their learning in a holistic way, as we will discuss further below.

In both cases, there was another element that guaranteed that the outcomes chosen were attainable and that was the clarity with which they were understood and communicated by the course controllers. In Case 2 the course controller and designer was very clear that the course outcomes all related to "doing engineering in context". This phrase, which embodies both big ideas and performance, was used as a unifying principle in the design of the various projects on offer, and strenuous efforts were made to communicate it to all of the very large number of teaching and tutorial staff. In Case 1, students were introduced to the norms and expectations of portfolio assessment from their first semester through dedicated instruction sessions and constant reiteration in classroom discussions, workshops and tutor-group meetings.

In terms of our alignment model (Figure 1) both of these courses articulated what students should be able to do and worked hard to communicate that intent to both teaching staff and students through clear articulation of the logic in class.

After successfully completing this course you should be able to:
1 Engineering Design: demonstrate ability to approach a complex and realistic engineering design task through:
a. clarification of the scope of the task;
b. development of project requirements including data collection and analysis of previous relevant work,
c. generation and critical evaluation of alternative conceptual designs,
d. detailed design, prototyping, and build of the chosen solution; and
e. dissemination of results.
Your design should be undertaken using a systems approach and should demonstrate an ability to make basic engineering calculations and conversions using different units.
2 Information Management: locate, evaluate, use and cite information (using the Harvard convention) from a variety of media including print, engineering drawings, and electronic sources;
3 Communication: demonstrate professional engineering-standard written, oral and graphical communication skills through appropriate use of software where relevant;
4 Project Management: demonstrate appropriate use of basic project management processes, tools and record keeping;
5 Team Work: work effectively in an engineering team, identify the characteristics of effective team work and critically evaluate personal and peer contributions to team processes;
6 Engineering Sustainability: demonstrate competence in critically interpreting the concepts of sustainability , and incorporating these principles in the engineering design process;
7 Personal Development: demonstrate an ability to manage your own time and learning and reflect critically on personal professional development;
8 Professional Development: understand the responsibilities of a professional engineer and the importance and relevance of risk management, health and safety, and ethics in that role.

Figure 4: Case 2 learning objectives, metropolitan, large cohort, Demo Day assessment

Matching assessment to objectives

The EWB Challenge requires participating student groups to submit a group project report and give a group oral presentation if they want to be part of the competition. Interestingly, even universities who did not take part in the competition chose to require these assessment items and they appear to be fairly common methods in project and team based courses. But how well do they actually demonstrate student learning, especially in a team environment? The report stands proxy for learning outcomes and we assess how good the report is, but does the production of the report in itself guarantee that the desired objectives have been met? Our two cases here asked these questions and redesigned their assessment to get more direct evidence of learning.

Case 1 Portfolio assessment

The students in Case 1 completed group work on projects, wrote reports and did some building of models/prototypes just as students in other universities did. However, here they received no marks directly for this work. Instead they were expected to collate all reports, feedback comments, online discussions and everything that might constitute evidence of learning into a portfolio that could serve as source material for their individual reflections on how well they had attained the objectives of the course.

From the student perspective, the portfolio was seen as helpful in focussing attention on the learning process and aspects of content they might not otherwise spend much time on.

Incidentally, the students in the following focus group excerpt demonstrate that they are developing a true reflective capacity in being able to trace how this helped with that.

> *Female student1: I think it is beneficial because it makes you think about it seriously, whereas if you didn't have to do it, you wouldn't really think about where your weaknesses are.*
>
> *Interviewer: You wouldn't do it, I'll tell you.*
>
> *Female student1: Yeah. So it definitely makes you think about things that you wouldn't normally think about.*
>
> *Male student 1: I think it helps you realise what you've learned as well, like you may have learned it, but then it's just like subconsciously. Whereas, when you actually have to write about it, you go 'Oh yeah, I really did actually understand that because of this, and it helped me with this project'.*
>
> *Male student 2: It's almost like starting a portfolio. Like, once you've written down something that you've learned it, you can point to it. Cos you need to provide evidence that you've met the learning outcomes, and that just helped, just because…. [Focus group 1, 7 Sep 2011].*

Perhaps because the portfolios were used every semester, students accepted them readily and did not complain about not being directly marked on the report. Just the opposite, they felt that the portfolio was a truer reflection of their learning than other forms of assessment. Because they have to identify evidence of their own learning they are pushed to work harder, think about things they wouldn't think about otherwise, and articulate for themselves where learning happened and where weaknesses are. This not only provides a clearer picture to assessors, but gives the students confidence and clarity. While many courses use objectives that include the word demonstrate, this form of assessment ensures that every student actually does so by making sure students can say what they have learned and how well, and what it helped them to do.

Case 2 Public demonstration of a prototype

The most innovative aspect of Case 2's assessment practices was the Demo Day (which has been reported elsewhere (ref present authors). The very public nature of this event requires a different level of performance from the students and goes far beyond the normal kind of powerpoint-driven explanation for rationale or classroom demonstration of a model.

This form of assessment required a different kind of demonstration that students had attained the learning objectives. While different project groups approached the Demo Day slightly differently, there was usually some expectation that students would be able to describe the rationale for their design decisions and answer questions both before and after demonstrating their prototype. For instance, some groups had information stalls for each prototype where anyone could go up and ask about it and inspect documentation. While written reports can be used to infer outcomes such as professional development, there is nothing like seeing how well students respond to ill-formed questions from the public and the heckling of colleagues for informing judgements about just how well everyone in the team has done.

The common factor in both cases' assessment strategies was the requirement of a performance of their learning. While reports can be put together from the efforts of a subset of team members, or divided amongst the team so that everyone only masters a portion of the learning, a live performance of learning not only demonstrates what this individual has learned but adds to the learning through the extra reflection required and necessity for clear communication.

Gearing learning opportunities to assessment (and hence outcomes)

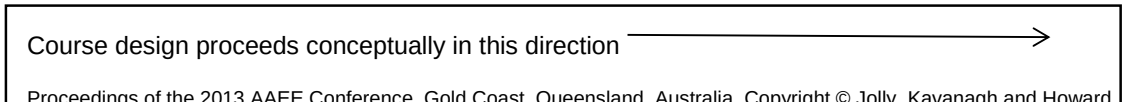
However, assessment and objectives are not the only things that need to be aligned. Learning opportunities too need to encourage the students to understand, acquire and practice the target outcomes. For all of the universities in our study this meant some form of teamwork sessions but there was some variation in how these teamwork sessions were organised, ranging from the highly structured class-time sessions to instances where students had to pursue their projects wholly in their own time. In the two cases being considered here, extensive time was provided for teams to work together on campus with tutorial/teaching support. In Case 1, besides continual tutorial oversight of developing ideas and performances, there were regular semi-formal interviews between tutor and groups about how the projects were progressing. This worked well for on-campus students but was less successful for the small distance cohort, who were meant to replicate the teamwork experience online. Unfortunately, the structure used successfully in the classroom does not provide the same learning context when the face-to-face dimension is removed. One of these students told us that in her estimation the online version of the course had "not enough content or enough structure or enough guidance" despite the fact that she acknowledged that the online facilitator attended online meetings, posted to discussion lists and sent out reminders and extra information. The online environment changed the experience in part because it changed student responses. As the same student said, regarding unequal effort in the team, "I think some people are more comfortable being…look, I wouldn't actually say it's lying, but saying something that doesn't actually really represent their true intentions, probably, online." In other words, the learning activity was not optimal for allowing the student to practise and demonstrate the target performances.

Quite apart from the ability to "hide" one's developing performance online, there is another aspect of alignment illustrated by the following story from one of the Case 2 tutors:

> *Because it was the first time we ran it we didn't realise how much the build would shift their focus initially…I found in my class it really became all about the build and they tended to forget about the fact that it was a village situation, so it was all about, initially, what can we do to maximize marks, and how are we going to get the best flow rate and there was a bit of a separation from what was happening in the village… And once I realised this, and I had three really good tutors as well, so they kind of pointed it out, and I noticed it as well, so then we started thinking ok, so these students are going to ignore salt for example, because it is going to make it more expensive and it's going to slow it down…and the tutors and I had a bit of a think about this and said "why are they doing this, that's obviously in the village, so they need to get rid of salt." And so then we sat down with the class and we had the conversation to bring it back to the village and we had to say "right, you can grab marks… but don't forget that you are going to justify why this works in the village," and I think that conversation then bought the focus back a little bit more to the village.* [Tutor interview 14/07/2011].

This tutor is describing how students orient their behaviour to assessment requirements, in this case the criteria set for the Demo Day demonstration. Because there were slight differences between what would work in a time limited demonstration and what was optimal for the actual context, there was a need to continually adjust the learning activity to make sure that students were working towards the right outcome. This illustrates that although the design of learning activities needs to be aligned to the desired outcomes, that is to allow students to practise the target performances, good design will not be enough to make sure that alignment happens. Teaching personnel and students all need to be clear about what the target outcome performance is and must work together to see that it is kept in view at all times.

We are now able to flesh out the model presented in Figure 1 with these examples:



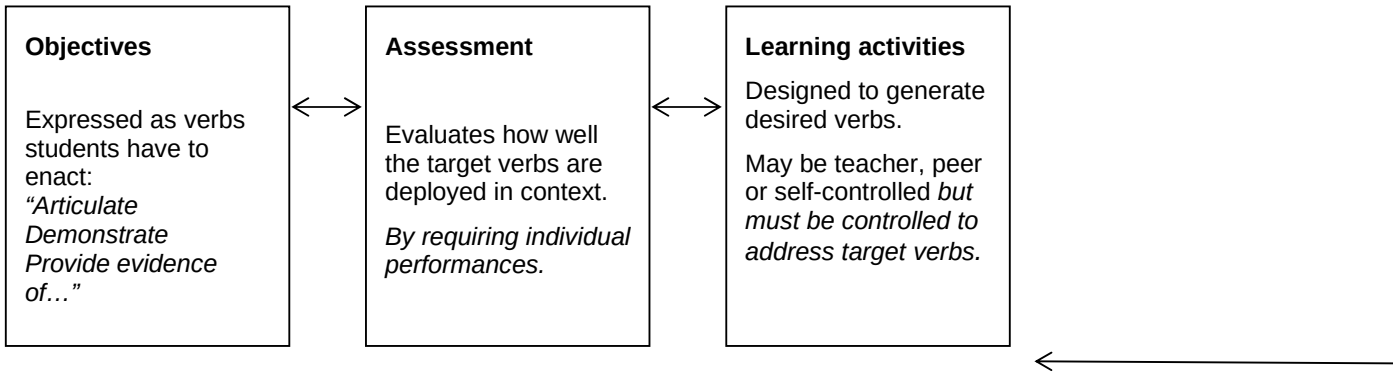


Figure 5: Alignment used in two cases. Modifications to original model in italics.

Conclusion

We have used these two cases to demonstrate what well-aligned assessment looks like and to urge course controllers to consider to what extent standardised assessment strategies such as group written reports actually demonstrate the learning hoped for. We concluded that the best course design and most informative assessment strategies will do three things:

1. Articulate learning objectives/outcomes using words that describe what you want students to know and do by the end of the course;
2. Make sure that the assessment strategy makes students perform whatever those objectives describe, not just some proxy for them; and
3. Make sure that the learning activities require students to practise the target outcomes and check that this happens regularly.

Both of our cases invest quite heavily in these strategies in terms of time and materials. Case 1 gives extensive formative feedback orally and in writing as well as marking portfolios and performing a viva voce. The curriculum has been redesigned so that this marking load covers the equivalent of two standard courses rather than just one and experienced portfolio markers develop strategies for reducing the time they need to spend in that activity to the extent that they claim it takes no longer than the equivalent of marking group reports. Case 2 allows 1000 students to build, test and demonstrate prototypes and that demonstrates a significant commitment to the learning outcomes which may not be possible in all contexts. Nevertheless it behoves us all to ask "to what extent do my assessment strategies provide evidence of what students have found out and can do?"

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