Assessment & Evaluation in Higher Education

ISSN: 0260-2938 (Print) 1469-297X (Online) Journal homepage: https://www.tandfonline.com/loi/caeh20

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Assessment & Evaluation in Higher Education
Vol. 34, No. 5, October 2009, 565–577

Routledge
Taylor & Francis Group

How to use (five) curriculum design principles to align authentic learning environments, assessment, students' approaches to thinking and learning outcomes

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In this article, we articulate five principles of curriculum design and illustrate their application in a third-year undergraduate course for environmental and ecological scientists. In this way, we provide a practical framework for others wishing to enhance their students' learning. To apply the five principles, we created a learning environment consisting of a broad range of learning resources and activities which were structured and sequenced with an integrated assessment strategy. The combined effect of this ensured alignment between the learning environment we created, the thinking approaches students used and the learning outcomes they achieved. More specifically, the assessment activities guided students by requiring them to recognise when their understanding was limited – and then to engage them in thinking approaches that would develop their understanding further. By providing a framework of thoughts, ideas and information, we sought to progressively enhance the sophistication of our learners' thinking. Thus, the assessment required students to integrate, synthesise and construct their understandings in ways consistent with the discipline and the professional pathways on which they had embarked. We intend that this illustration will act as a guide to other academics to adopt the same principles in their teaching.

Keywords: curriculum design; assessment; authentic; deep learning; learning; engage-ment; science education

Introduction

To guide students to create increasingly complex knowledge structures requires us to progressively scaffold their thinking. This article discusses and illustrates five curriculum design principles used to inform the development of an innovative curriculum that is designed to guide students towards progressively more complex thinking and practice. These curriculum innovations were applied in a large third-year undergraduate course for environmental and ecological scientists taught in a large metropolitan university in Brisbane, Australia. Thirty-seven students completed the course.

Several well-known learning taxonomies specify hierarchies of intellectual skills and understanding for students' thinking. For example, Bloom's (1956) taxonomy and the refinements of that model by Anderson and Krathwohl (2001) focused on cognitive processes. Biggs and Collis' (1982) SOLO taxonomy focused on the products of

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ISSN 0260-2938 print/ISSN 1469-297X online

DOI: 10.1080/02602930802226502
http://www.informaworld.com

those cognitions. While Perry's (1981) work recognised the processes and motivations for moving to progressively more complex ways of thinking and conceptualising. As Perry illustrated, learners' progress often results in, and is motivated by, the realisation that one's current level of understanding is inadequate in some way. Cumulatively, each of these theorists recognised that learners' increasingly sophisticated thought processes result largely from a process of guided trial and error. To these insights, we add the important codicil: successful students' conceptualisation of the disciplinary content develops gradually until it reaches a position of common alignment with that of colleagues (Merriam and Caffarella 1991; Laurillard 1993). The authors recognise this as the minimum end-point for undergraduate learning outcomes in a discipline. But how can this ideal be achieved?

'High quality' learning outcomes should result from the interplay between students' learning efforts, the curricula and the teaching methods used (Bliss and Ogborn 1977; Laurillard 1993; Roth 1994; Leonard and Penick 2000). It is possible to infer the achievement of the desired learning outcomes by observing (through assessment) improvements in the way students acquire, process and synthesise information (Marton and Booth 1997) and subsequent improvements in their skills. These sorts of outcomes occur when students adopt a deep, rather than a surface approach to their learning (Marton and Säljö 1976, 1984).

It follows that one of the truisms to emerge from learning research over the last quarter of a century is that the surface–deep categorisation of learning approaches (and consequent outcomes) proposed by Marton and Säljö in 1976 still holds true as an underpinning principle describing students' approaches to learning. Other categorisations have been proposed and these essentially maintain a surface–deep distinction at their core. For example, the inclusion of a 'strategic' approach to learning by Richardson (1990) recognised more formally the role of motivation in the choice of approach in different learning contexts. It did not represent a departure from the deep–surface distinction.

Students adopting a deep approach to learning characteristically exhibit: an explicit intent to develop their own understanding of material (Entwistle and Tait 1990; Biggs 2003); knowledge which is highly structured (Biggs and Collis 1982; Boulton-Lewis 1998); an ability to apply their own and other's ideas/concepts to new situations (Ramsden 2003); and a highly developed integration of knowledge (Biggs 2003). These qualities manifest themselves in student performance as:

(1) enhanced understanding (Bodner 1986);
(2) enhanced comprehension (von Glaserfield 1987; Leonard and Penick 2000);
(3) more spontaneous venturing of ideas (Chin and Brown 2000);
(4) more elaborate explanations that describe mechanisms and cause–effect relationships (Entwistle and Hounsell 1975) or refer to personal experiences (Brookfield 1985);
(5) questions that focus on explanations and causes, predictions, or resolving discrepancies in knowledge and engaging in theorising (Chin and Brown 2000); and
(6) constructing more elaborate, well-differentiated knowledge structures (Pearsall, Skipper, and Mintes 1997).

Clearly, these are the kinds of qualities we would like to help our students aspire to and to develop. As Biggs (2003) explains, some students will spontaneously engage in study behaviours that do this, others need some direction. To that end, we should recognise that as educators we are in a powerful position to influence students' approaches to learning (Biggs 2003). Indeed, it seems central to Biggs' (2003) argument that it is *only* by ensuring that students engage in particular behaviours (cognitively) that the quality of their learning outcomes can be guaranteed. To do so, the principal tools available are the curricula (Powell 1982), the teaching methods used (Marton and Booth 1997; Kember 1998) and the ways students are assessed (Rowntree 1977; Boulton-Lewis 1998; Biggs 2003). By manipulating these in deliberate and controlled ways, it is possible (in principle) to guide, support, steer – perhaps even *oblige* (Kuh 2007) – students to engage in study behaviours that are consistent with the achievement of high-quality learning outcomes.

Students adopt their own learning strategies to achieve 'success' in ways they believe will suffice to meet assessment requirements (Biggs 2003). Therefore, to maximise the quality of student learning outcomes, we must construct learning environments that ensure students' adaptive responses to our curriculum are congruent with our aims (Boud 1982; Biggs 2003; Ramsden 2003), something which Biggs (2003) calls 'backwash'. Through constructively aligning desired learning outcomes with assessment tasks (Biggs 2003), it is possible to remove incentives for reproduction of material (what we call '*negative* backwash', or a surface approach) while providing students with the opportunity to demonstrate deeper engagement with their learning ('*positive* backwash').

Curriculum design 'principles'

Biggs' 3P model of learning and teaching (2003) guided our articulation of the five curriculum design principles we discuss and illustrate. Biggs recognises all components of the 3P model that are connected to each other because 'they all form a *system*' (2003, 19, emphasis added). Later he stated, '… all these aspects of teaching are mutually supportive; each is an integral part of the total system …' (26). Biggs also states that capitalising on the things that are within our control (to get students to use higher order cognitive activities) is what good teaching is all about (4–5). Illustrating how to do this (to take control over a system in ways that get students to use higher order cognitive processes) is what this article aims to do. To that end, the following principles were adopted:

To maximise the quality of student learning outcomes, we, as academics, need to develop courses in ways that provide students with teaching and learning materials, tasks and experiences which:

(1) are authentic, real-world and relevant;
(2) are constructive, sequential and interlinked;
(3) require students to use and engage with progressively higher order cognitive processes;
(4) are all aligned with each other and the desired learning outcomes; and
(5) provide challenge, interest and motivation to learn.

The effect of applying these principles is to manipulate the learning system in ways that require students to adopt a deep learning approach in order to meet the course's assessment requirements – which, in turn, meets the desired course learning outcomes.

Before proceeding, Biggs (2003, 6) states a critical need for contextualisation of principles to the teaching context in the following way: 'Wise and effective teaching is not … simply a matter of applying general principles of teaching according to rule: those principles need adapting to your own personal strengths and to your teaching context'.

It is also appropriate to note that there have been reservations expressed in relation to Biggs' idea of constructive alignment – though not always directly. More specifically, there is a body of opinion which is uncomfortable with the specification of detailed objectives in advance (the precursor of constructive alignment). Much of this body of opinion has its roots in the work of Eisner (1985) when he talked about expressive objectives. A related perspective has its origins in what Michael Polanyi called personal knowledge and the tacit dimension in that knowledge (Polanyi 1962, 1967). These ideas start from a premise that 'we can know more than we can tell' (Polanyi 1967, 134), and by extension, the idea that the specification and achievement of educational objectives constrained by curriculum alignment is philosophically wrong. Such a philosophy implicitly negates freedom of thought – even if this is only to some extent – when freedom of thought cannot actually be so constrained. While acknowledging this body of opinion, for the purposes of this paper, we are adopting the constructive alignment model because we, and many others, think it has a lot to offer. For this reason, we use language such as 'require' and 'oblige' in this paper, although we (silently) applaud the free minds and behaviours with which we work and upon which we have only influence, not control.

The students' learning environment

The five principles of curriculum design we articulated above are used to require third-year ecology and environmental science students to learn about science through practising the scientific method. Although this article illustrates the application of these principles in the area of science, the approach holds broad applicability across nearly all disciplines. We created a scaffolded learning environment with an integrated assessment strategy that required students to integrate, synthesise and construct their understandings in ways to allow them to think like professionals. To help learners achieve this goal, we guided their critical thinking, analysis and problem-solving skills through our approaches to teaching, via a unifying assessment strategy, and through the learning support and learning environment we created.

Students needed to solve a number of challenges using data gathered from studies of the tropical island of Lys. Lys formed the central element of a case study through which students learned the practical and theoretical underpinnings of terrestrial ecology. The case study comprised a web-based tour of the island. The tour provided students with, amongst other things, streamed video footage of the lecturer atop the 3700m summit of the island's active volcano and of plant communities on the island. The students also engaged with a graphical tour of the island. Students could choose amongst virtual renderings of the geographic or topographic features of the island, or maps depicting results of survey data that identified the distribution of the plant and animal communities. For various locales, students accessed images of plant, animal and geological aspects of the island. Brief explanations accompanied each image, providing a broader context with which students could engage. To provide finer scaled resolution and further distilling of the data, the students engaged with three scientific papers, published following a scientific expedition to the island. To add further authenticity to the learning experience, students received datasets that the course teaching team were simultaneously analysing for their own research. Together, these resources required students to engage in the cognitive processes of synthesis, integration and application of their understandings to address assessment criteria. Students engaged with the learning environment, analysed the data, developed hypotheses, tested and refined those hypotheses and predicted outcomes in terms of the distribution and abundance of organisms across the island. They derived their understanding of the past, present and conjectured future distributions according to the conceptual models they had developed. Applying the curriculum design described below, allowed the academics to orchestrate and guided students' learning journey.

The students' learning journey

Curricula innovations, which relate primarily to any one of the five principles generally also relate to one or more of the others. Thus, in writing this article, separating out the curricula innovations, which were designed to meet the challenge of *each* principle, and presenting them serially, would be artificial and result in repetition. Instead, the article describes the cumulative nature of the students' experience of the course. It presents the *sequence* of the course teaching, learning materials and tasks. By doing this, we convey the journey of discovery that the students themselves experienced. In this way, the presentation also demonstrates how the combination of curricula innovations addresses the five principles, how these innovations resulted in students' willing participation, how the 'system' that is the course obligated students to engage in higher order cognitive processes, and that this cognitive-behavioural response is entirely consistent with the achievement of the course learning aims. The sequencing of course components is summarised in Table 1.

Table 1. Sequence of course components.

Week	Frame	Lectures	Resources	Website	Practicals	Assignments
1	The island of Lys Developing an understanding of the origins and evolution of Australia's flora and fauna, ecological principles and processes	Module 1 Paleo-diversity	Provision of course outline and handouts	Fully developed and integrated website with additional learning resources such as maps and reports	Practical 1	
2						Assignment 1
3			Handouts		Practical 2	
4						
5			Handouts			
6						
7					Field Trip	
8		Module 2 Eco-principles				
9			Study guide			Assignment 2
10						
11		Module 3 Restoration ecology				
12			Study guide			Assignment 3
13						

What's the course all about? Why do I have to do it?

When students commence a course, we know that there is sometimes some degree of choice over the courses they have selected. It follows that, where there is this choice, there is also some degree of thought about 'Why should I do this course?' and 'Why is it relevant for me?' Given that adult learners are purposeful, it is reasonable to suppose that even when a course is compulsory, the primary thoughts in students' minds will include: 'What is this course all about? and 'What do I have to do to get through it?' Responding to these questions relates directly to the first principle: *develop materials, tasks and experiences that are authentic, real world and relevant.*

Thus, students were provided with a course outline that specified (first and foremost) the rationale for the course. (This provision was also university policy.) The rationale made clear the real-world relevance of the course in the form of statements addressing *needs*. Specifically, ecologists need to understand the origins of Australian flora and fauna, and need to use this understanding to derive and apply ecological principles to a developing understanding of ecological processes. This is in turn needed if ecologists are to apply that understanding to real problems, they will encounter as ecologists. That is to say, it is relevant and necessary to their future employment and scientific contributions.

A well-constructed rationale leads almost inexorably to a specification of course aims and objectives. Achieving this was important, in part because doing so relates also to the alignment principle (Principle 4) and in part because it helped to create a narrative that students could more readily engage with (Principle 3). The specification of the rationale, aim and learning objectives ensured that each of these elements was mutually dependent and entirely consistent with each other. By doing this, a clear sense of purpose and direction was established for students thereby providing the foundations to answer their question 'What do I have to do to get through this course?' (This question is returned to later when discussing assessment requirements.) The clearer the answer to this question is to the students, the more likely it is that they can direct their own study efforts – in principle, without so much assistance from the teaching team.

To create authenticity as well as relevance, the course materials, tasks and experiences were constructed around material derived from scientific study of the tropical island of Lys (pronounced Lease), situated off the coast of Queensland, Australia. This strategy is consistent with advice from Kember (1998) who recommended the use of vivid examples and contextual learning to facilitate student engagement with material. This strategy relates to Principles 1, 3 and 5.

Using several publications arising from a scientific expedition to Lys in 2002, as a foundation, learning resources for the course were developed. These consisted of: lecture-based material; paper-based learning resources (e.g. handouts); web-based study guides; practical notes and materials; and on-line content (e.g. readings, links to Websites, etc.). In all cases, the nature and quality of these materials, and extracts of the original papers (covering the island's history, mammalia and fauna) were very high. The distribution and abundance of the plants, animals and landforms of Lys, together with its isolation, provided an ideal and authentic model system in which to examine dynamic ecosystem processes. The full significance of this will be revealed at the end of this article.

These materials facilitated high-quality engagement with the learning tasks since students found the materials of interest easy to understand, and associated their work with a sense of involvement, challenge, fulfilment, achievement and satisfaction (Connell 1967; Svensson 1977; Brookfield 1985, 1995). Consequently, students also spent more time on the task of learning (Biggs 2003).

How am I going to get through this course? What do I have to do?

After grasping the reason for and relevancy of the course, students wonder what they have to do to get through it. Naturally, their attention is directed to the course requirements – principally the assessment requirements. The course design was built on the understanding that the assessment tasks held together and sequenced all the other course components. Students recognised that they *have* to complete the assessments to obtain the marks which (if they are successful) would result in their desired grade (Ramsden 1993, 2003; Tang 1994). Students also recognised the obligation (even if only because of the assessment due dates) to complete these tasks in order. It follows that provided these requirements involve cognitive activities which align directly with achievement of the desired learning outcomes, *and* provided all the other components of the course are overtly and directly related to the successful achievement of these assessment tasks, then students will choose to engage with these components and assessment tasks and will achieve the desired outcomes.

Responding to this imperative directly addresses Principles 2, 3, 4 and 5:

(2) Develop materials, tasks and experiences which are constructive, sequential and interlinked
(3) Require students to use and engage with progressively higher order cognitive processes
(4) Are all aligned with each other and the desired learning outcomes
(5) Provide challenge, interest and motivation

Firstly, to illustrate ecosystem processes to students and to provide a sequenced structure to the course, the course was divided into three sequential and interlinked modules. These modules were designed to be cumulative in their effect (Principle 2). Each module had an assessment item directly associated with it (Principle 4). Each assessment item – like the modules themselves – built on the preceding ones (Principles 3 and 4). Students needed to understand the materials in the previous module before progressing – thus ensuring a cumulative development of cognitive skills and understandings on a sound foundation.

Constructive, sequential interlinking of learning experiences (Principle 2) was further supported by two hours of lectures each week being directly coupled with an average of two hours of practical work. In other words, the content and timing of practical work was *deliberately* and *obviously* related to the lectures. Lectures and practical work were also deliberately and obviously related to the assignments – which were directly related to the desired learning outcomes (Principle 4). The practical work was distributed between laboratory, tutorial and field-based work to further boost authenticity (Principle 1) and to add interest and motivation through variety (Principle 5).

Two of the practical exercises had an entirely formative function. That is to say there were no marks awarded to these exercises. However, engagement with these activities formed the basis for students' approaches and understandings that they required to complete their assessable work. Given students' engagement, and formative feedback in tutorials, and since failure in the practical work could not adversely affect students' grades, students associated no risk with participation. By engaging learners with formative tasks which had inherent interest and challenge, learners were challenged and interested (Principle 5) without incurring damage to their motivation through peer competition or performance anxiety.

The ways in which the assessment addressed Principle 3 requires much greater explanation. Notwithstanding that the learning environment, and students responses to it, is a system (Biggs 2003), the success or failure of this aspect of the system is critical to the achievement of successful learning outcomes. The assessment tasks themselves must engage students in a sequence that demands that they use progressively higher order cognitive processes.

To achieve this, for each assessment item the questions asked were framed in a divergent fashion, allowing each student the opportunity to pursue and develop their own knowledge and understanding within the context of the course aims and goals (Principle 3). In addition, each module (lectures + practical + assignment) was sequenced to provide the requisite knowledge to begin studying the module that followed (Principle 2).

The progression from Assignment 1 to 2 relied on developing *a critical knowledge framework* as an outcome of Assignment 1. This progression was augmented through a five-day field trip to a nearby island, timed to occur after students had completed Module 1 and had submitted their first assignment. The field trip afforded students a first-hand opportunity to consolidate the ideas and knowledge they had gained thus far, and to introduce them to key concepts they would consider in Modules 2 and 3. Students recognised that the classroom learning really did have practical and significant real-world implications. Students commented that they were excited by being able to 'apply what [they had] learned to something real'. The reality of the field trip provided a bigger and more complex context for students' learning which stimulated more questions in their minds and motivated them to find out more – if for no other reason than strategically accumulating thoughts and ideas to help them to complete Assignment 2. Thus, students recognised the inter-connectedness between the materials covered in lectures, practicals, tutorials and field trip, and realised that they all act to constructively assemble the knowledge and ideas necessary for them to complete the assessment tasks.

The progression from Assignment 2 to 3 depended on developing a focus on *understanding the theoretical principles* as an outcome of Assignment 2. Finally, the success of Assignment 3 depended on students developing an *application focus* requiring them to actively test their understanding. This sequence is deliberately consistent with progressively achieving higher order cognitions.

What follows examines the requirements of Assignment 1 to illustrate how this works in more detail.

Students were asked to undertake the following two tasks:

(1) Using palynological records from the island of Lys, explain changes in the island's flora and fauna over time.
(2) Explain how the island's flora and fauna came to achieve their current distributions.

Completing these tasks requires students to discuss the dynamics of Lys' plant and animal communities and ecosystems through time. To do that, students have to read, understand and apply the information contained in the handouts and practicals. To successfully complete the practicals, students must engage with and construct knowledge from the learning resources provided.

By providing a structured *assignment-based* assessment item, students received a framework around which they could construct increasingly complex knowledge. This framework in turn helped formulate their answers to the assignment. Aligning this assignment with lectures, handouts and practicals maximised the chances that students would recognise that all these components provide the foundations necessary for them to complete the assignment. The curriculum design objective was to set up the course in such a way that when faced with the assessment task, students would see the association between it and the other course materials and think: 'I'd better read some of the resources provided and do the practical exercises – it will help me do the assignment'.

This manipulation of students' behaviours is not entirely one way because students' initial responses to the perceived demands of the assessment are strategic: they asked themselves how they could do the tasks to a standard that would match their desired grade. We are simply capitalising on students' adaptive response to the assessment demands to direct their learning. Simply, students *must* complete the learning tasks through engaging with the learning resources we provide before they can answer the assignment.

How did this actually work in practice? What follows examines the tasks associated with the practicals linked to Assignment 1. Here appears an illustration of the process students traversed to achieve their learning outcomes.

The first practical involved students examining *pollen records* to determine the plant species composition of Lys over a span of 20,000 years. The initial learning outcome was that students used the pollen records to derive some ecological principles about the distribution of plant communities. (Further understanding of these principles was later developed in Module 2.) Next, however, students discovered that the pollen records did not match the current distribution of the plant communities on the island. Students began to question the validity and assumptions associated with the collection and interpretation of such data. They realised that while data of this kind is necessary, it is not sufficient to provide explanations of the current and past distribution of the island's flora and fauna. Students recognised that they require additional information.

The second practical required students to investigate animal *fossil records* from two localities on the island. Following their extended analysis, students derived further ecological principles (on which we also expanded in Module 2). Students realised that the animal fossil data could tell them that certain animals occurred during times when certain plants were abundant. However, students recognised that without specific ages of the animal fossils that they could not determine when the overlap between plants and animals occurred. In combination, the outcomes of practicals and tutorials demonstrated to students that the fossil data augments the pollen data – thus allowing students to derive more sophisticated models of Lys' past.

Students recognised the importance of, and the inter-connectedness of, this information because it formed the basis of the knowledge/information they needed to complete Assignment 1. Assignment 2 built on and similarly required the understanding that students developed in Assignment 1.

In summary, the overall design of the assessment items and associated resources make it possible to ask many 'what–if' type questions designed to guide the constructive development of critical thinking processes (Brookfield 1985; Bodner 1986; Halpern 1998, 1999). Specifically, through the nature and sequence of the assessment tasks, we were able to oblige the students to synthesise a broad range of information, identify useful resources, formulate and test hypotheses, and ultimately, to apply their developing understanding to novel problems. Thus, the cognitive tasks required to successfully complete the assessment items derive from an engagement between the students and the learning materials, which is driven by those assessment tasks (Boud 1980; Powell 1982; Biggs 2003; Ramsden 2003).

Before concluding this paper, some minimal evaluation data are presented to demonstrate that the desired learning outcomes were indeed achieved, that students commented on the alignment of the curriculum with the achievement of these outcomes and their study behaviours, and that such outcomes can therefore (more likely) be attributed to the intervention rather than to some other explanation.

Students recognised that the curriculum design required engagement and subsequent synthesis of their understandings:

> The assignments were one of the best features of the unit because this is the one way we can tie in all our knowledge and relate it all to further thinking.

Equally critical though, the design required learners to engage with and test their understandings through hypothesis generation and application of their knowledge – crucial components in their repertoires as professional scientists.

> The whole Lys concept really provided the opportunity for exploration and novel thought. It really encourages me to think about what we are learning in class and apply it to an unfamiliar situation, i.e. Lys.

Students' perceptions of enhanced enjoyment of their learning corresponded with improved learning outcomes. Examination of learners' various summative assessment tasks demonstrated responses that featured deeper and more sophisticated understandings, holistic and well-differentiated knowledge structures, and high levels of synthesis and integration. To evaluate the quality of students' understandings, their work was compared with the categories of Biggs and Collis' (1982) Structured Observation of the Learning Outcome (SOLO) taxonomy. Students' work demonstrated significantly higher proportions of responses at multi-structural, relational and extended abstract levels than the work of students completing the previous year's class.

Conclusion

Following the specification of five principles of curriculum design, this article has illustrated the way teaching materials and resources can be developed to cohere together and conspire to oblige the students to engage with their learning in a deep manner.

It has been argued that assessment can and should take the central role in curriculum design because it is one of the first things students look at and because it defines the curriculum for them. Consequently, assessment drives activities that students engage in. These activities underpin their learning, so careful design of an assessment strategy (not tasks or items) can ensure that the students engage with the associated learning resources provided and in learning activities that lead to achievement of the desired learning outcomes.

Epilogue

The students suggested one area to improve the course in successive offerings. They wanted a field trip to Lys, rather than to nearby Fraser Island. We explained the three major challenges in organising a trip to Lys:

(1) the pristine environment of Lys is protected to prevent human damage;
(2) as we had explained in class and in the published papers given to the students, Lys' position 626 km off the coast of Queensland precludes easy access; and
(3) Lys is entirely fictitious – it does not exist anywhere, except in our imaginations.

The fictitious island of Lys was constructed because no real environment could serve so well to illustrate the concepts and develop the skills students needed to master. Although the island was completely fictitious, it provided an entirely authentic learning environment with which students could engage.

Importantly, however, although the island was contrived to provide a learning environment to facilitate student learning, this is not the primary message to take from this article. Rather, the principal proposition is that the careful application of the five specified principles of curriculum design aids in the creation of learning experiences, which produce superior learning outcomes, because they help to, almost though never quite literally, 'oblige' students to engage with *all* the learning materials we designed, and thereby to adopt deep learning approaches.

Most educators could apply the five principles presented in this article (in their own context dependent ways) to create a similar or superior learning environment within their own discipline. In this paper, we suggest what we need to build resourcefulness into our professional repertoires in a time of resource constraint to improve our students' learning outcomes.

Notes on contributors

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