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Taking 'Concepts in Chemistry' to completion: redesigning a first-year undergraduate module

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Introduction

The module 'Concepts in Chemistry' (CH4005) was designed in response to a requirement for a new curriculum and was introduced to the first-year undergraduate 'Molecular and Pharmaceutical Sciences' (MPS) student cohort in 2012/13. The module comprises several elements, which previously made up two separate modules and although these were integrated smoothly into a single module, this paper discusses the evaluation of the module one year after its inception and suggests some options for a redesign.

As its name implies, CH4005 is designed to act as a broad-based primer in Chemistry for students undertaking both Chemistry and Pharmaceutical Sciences degrees. This duality means that there is significant spread in the subject knowledge and abilities of the students, with expertise (or lack of) in, for example, mathematics causing a polarising effect in the attitude of the students, mirrored in the assessment output. Prior to redesign, the module featured only four lectures in mathematics, two of which were at a pre-GCSE level and the other two which were of A-level equivalence. This sharp discontinuity led to the majority of the student cohort apparently struggling with the transition and needed to be addressed through module redesign.

Furthermore, the UK government has expressed the view that science should exist at the heart of government policy and has recently emphasised the key role that Science, Technology, Engineering and Mathematics (STEM) will play in the future of the UK economy with STEM graduates being envisaged to form the backbone of science and industry. The module redesign had therefore to be fully congruent to this consideration as well as adhering to the specifications of the relevant accrediting body: The Royal Society of Chemistry (RSC).

Approach

The meld of a student-centred pedagogy and the requirement of an academic curriculum (i.e. content-driven) was carried out through the application of the outcomes based cyclical approach presented by Jenny Moon in 2001 (Gosling and

Moon, 2001). Overall module coherence was also reviewed in order to ensure continuing constructive alignment, as recommended by Biggs (1996).

The evaluation of a module fulfils a variety of purposes, from acting as a quality assurance review and providing feedback on the effectiveness of teaching, through to enabling the students to have a voice (Hounsell, 2009). Here, feedback was gathered both from the students and staff, with suggestions and concerns ranging from the need for the Virtual Learning Environment (VLE) to be amended, which is a perennial concern and may stem from lack of early directed tuition in using VLEs, to the performance and, significantly, attendance of students dropping off for the short summative assessments taken during the year (rather those 'bookending' the module).

Level descriptors state the knowledge and skills a student is expected to have mastered at the end of a particular level (Moon, 2006). In conjunction with the aims, these provide a frame on which to hang the learning outcomes. This structured approach is, however, not without its critics: Hussey and Smith (2009) have raised concerns about their versatility, speculating that common level descriptors would hinder the ability to produce appropriate learning outcomes for more than one discipline i.e. what's good for the goose is not always good for the gander. The Southern England Consortium for Credit Accumulation and Transfer (SEEC) credit level descriptors (SEEC, 2010) are a set of level descriptors in common usage in Higher Education faculties across the south of England and were deemed the most suitable given their balance of detail, clarity and applicability.

Chemistry is one of three subjects for which pilot benchmark statements were originally developed by the Quality Assurance Agency for Higher Education (QAA) (Quality Assurance Agency, 2007). They were produced in response to the Dearing review (National Committee of Inquiry into Higher Education, 1997) that suggested that the standard of higher education in such subjects was being eroded, an implication hotly debated to this day. The RSC has also stipulated the threshold standards that must be met in order for Chemistry degree programmes to be accredited (Royal Society of Chemistry, 2012). Here, the QAA benchmark statements and the RSC accreditation standards were applied in concert with the SEEC credit level descriptors.

Jenny Moon (2007) captured the crucial difference between aims and learning outcomes succinctly when she stated that: *"aims are therefore more about teaching and the management of learning, and learning outcomes are more about learning."*

In essence, an aim should "provide direction" (Moon, 2007). Over the last decade, learning outcomes, have, however, come to have a significance not originally envisioned when initially proposed. Learning outcomes are now the workhorse of course design and redesign; but as with the level descriptors, there are some detractors who believe that due to the difficulty in defining truly well-written learning outcomes and rigid compartmentalisation resulting in some topics being

circumvented, learning outcomes should become merely another tool in the curriculum designer's bag (e.g. Scott, 2011; Maher, 2004). However, when properly expressed and constructively aligned (Biggs, 1996), learning outcomes are, from this author's viewpoint, a distinctly valuable asset. Much has been published on how best to write learning outcomes, with Moon (2007) and Scattergood (2008) providing two excellent reference sources. For CH4005, both the aims and learning outcomes were deemed still to be suitable and were therefore not adapted during the redesign.

Module redesign

The original module design incorporated three distinct assessment components: (1) regular summative assessment through ten mini-tests, (2) coursework and (3) a final examination. One of the key issues raised during the collation of feedback was the possible over-assessment of the students on this module, reflecting the dip in performance mid-year. Although the main argument for having a high proliferation of assessment tasks is to provide the students with frequent feedback, enabling them to improve, Bailey (1999) has observed that for Chemistry students, this argument does not take account of the different learning characteristics of the student and encourages surface learning. One school of thought suggests that there is actually no such thing as 'over-assessment', merely an imbalance of formative to summative assessments (Price *et al.*, 2011). Certainly, given that the majority of assessment activities in CH4005 are problem-based with feedback only given after the assessment event and normally only relevant to the specific questions, one could question the efficacy of the assessment and feedback process here.

A modified range of assessment components was therefore proposed with more emphasis placed on formative assessment (hence reduction in summative assessment), and with educational effectiveness weighed against resource efficiency in order to identify the most appropriate assessment method (Higgins, 2010). Formative assessments include quizzes disseminated through the VLE providing immediate feedback, and the 'one-minute paper' (Angelo and Cross, 1993). This efficient technique can realise timely feedback for tutors and immediate cognition of the salient points of the teaching session by the students at a low resource cost.

It has been stressed by Ryan (2011) that laboratory report writing, a crucial skill for a budding scientist, has long been a bug-bear for 1st year undergraduate chemists. Two formative assessment methods have been identified that could provide timely and relevant feedback to the students before their summative report write-up. First, pre-lab questions (re-phrased in a multiple-choice format) will be put online, providing instant feedback. Secondly, pre-completion feedback (known as feed-forward) will be given on the students' *draft* lab report write-ups. Such a tool has been found to enhance student performance and deep learning through stimulating engagement and tutor-student interaction (Price *et al.*, 2011). This will be carried out through peer-review albeit supported by tutors, giving the students an

opportunity to interact with the assessment criteria, on which they will base their grading and feedback.

Although an integral aspect of assessment, the use of assessment criteria as an *effective* tool is relatively rare (Moon, 2007), which may stem from a concern that overly detailed assessment criteria may risk engendering shallow learning. However, although generalised grade assessment criteria are in wide use across higher education, they are imprecise and are unlikely to imbue the students with a clear aspirational path to achievement. It is clear that a balanced approach must be taken in order to ensure that abstruse assessment criteria are not defined.

However, it has been noted that research suggests that, possibly surprisingly, the mere existence of assessment criteria do not themselves inspire students to produce better work (Price and Rust, 1999). Rust therefore suggests active engagement with the assessment criteria (Rust, 2002), a recommendation which inspired the suggested peer-review 'feed-forward' session.

One of the key redesign features for this module is the provision of a 'blended learning' component, where the majority of the mathematics would be taught as e-learning content. Blended learning has successfully been applied to many Higher Education courses, with one such modification reported by Williams and his colleagues (2008), where the pedagogy of an Inorganic Chemistry module was enhanced through the formation of an 'enhancing' blend. Such a blend is also ideally suited to this module, where the student-centred approach to the e-learning mathematics element should enable the students to work at their own pace and at an appropriate level. A range of multimedia content will be developed, including videos and self-assessment quizzes, through WebLearn. These will categorised into a number of clearly defined content areas, allowing the students to select the most appropriate sections for their individual needs, and providing a flexible arena of self-paced and self-managed learning. Additional support will be provided in the form of weekly voluntary workshops, giving students both learner-to-tutor communication and peer support.

However, as with any mode of teaching, the learners must be considered first and foremost – one aspect frequently overlooked is the learners' competence at ICT. For the current generation of students, known as the 'Millennial' generation (Sandhu *et al.*, 2012) their familiarity with technology often masks paucity in critical and evaluative skills for information transmitted electronically (JISC, 2009). Given the broad student profile across London Metropolitan University, even the assumption that all students are comfortable using computers is likely to be false; hence all e-learning aspects must be incorporated sympathetically.

The process of evaluation itself is cyclic (Hounsell, 2009) and will continue for this module. However, one new source of evidence will be incorporated into the evaluation strategy for this module: the analysis of tracking data in the VLE, which

should inform on the degree of engagement that the students have with the technology (Anagnostopoulou *et al.*, 2008). The dominance of such technology across Higher Education seldom seems to correlate with evaluation of data logs, as is demonstrated by the relative dearth of literature on the subject. Could this be due to the inherently fixed granularity of the data leading to a necessity for further data mining, postulated by Hardy *et al.* (2008) or might it be that teaching faculties themselves do not have either the requisite knowledge or familiarity with the VLE software to be able to carry out relevant course evaluations using the data? Whatever the case, although the tracking data should quantify the student engagement with the technology, it will not necessarily mirror their engagement with the module as a whole and so a range of more traditional monitoring activities, such as attendance monitoring and assessments, will be used to supplement this.

Conclusions

The evaluation and redesign of CH4005 using the Gosling and Moon curriculum design model developed in 2001 showed that the aims and learning outcomes were aligned with both the teaching and learning activities and the assessment tasks. However, some recommendations have been made in order to alleviate an issue common to many 1st year undergraduate modules - that of bridging the knowledge gaps existent within a diverse student population without adversely affecting the quality and quantity of the subject matter. A blended-learning approach has therefore been postulated for the mathematics element of the CH4005 curriculum, giving students the opportunity to tackle the subject matter at their own pace and self-evaluate their performance. In addition, a range of formative assessments based on highly-cited pedagogical techniques have also been suggested, which range from the inclusion of the 'one-minute paper' and the provision of feed-forward rather than feedback.

References

Anagnostopoulou, K., Parmar, D. and Priego-Hernandez, J. (2008) *Final report to the HEA: Managing connections: Using e-learning tracking information to improve retention rates in Higher Education* [Online]. Available at: http://mancons2.middlesex.wikispaces.net/file/view/Final+Report+(Anagnostopoulou,+Parmar+%26+Priego-Hernandez,+2008).pdf (Accessed: 23 July 2013).

Anderson, L. and Krathwohl, D. A. (2001) *Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives,* New York: Longman.

Angelo, T.A. and Cross, K.P. (1993) *Classroom Assessment Techniques: A Handbook for College Teachers*,
2nd ed. San Francisco: Jossey-Bass Publishers.

Bailey, P.D. (1999) Assessment of Chemistry Degrees, *University Chemistry Education*, 3 (2), pp. 64-67.

Biggs, J. (1996) Enhancing teaching through constructive alignment, *Higher Education*, 32(3), pp. 347-364.

Bishop, R. and Eley, A. (2007) *Microbiologists and maths*, Microbiology today, 28, pp. 62-63.

Bloom, B.S., Engelhart, M.D., Furst, E.J., Hill, W. and Krathwohl, D. (1956) *Taxonomy of Educational Objectives. Volume I: The Cognitive Domain*, New York: David McKay.

Bloom, B.S., Masia, B.B. and Krathwohl, D.R. (1964) *Taxonomy of Educational Objectives. Volume II: The Affective Domain,* New York: David McKay.

Gosling, D. and Moon, J. (2001) *How to use learning outcomes and assessment criteria.* London: SEEC.

Hardy, J., Bates, S., Hill, J. and Antonioletti, M. (2008) Tracking and Visualisation of student use of online materials in a large undergraduate course, in Leung, H., Li, F., Lau, R., Li, Q. (eds.) *Advances in Web Based Learning – ICWL 2007.* pp. 464-474.

Higgins, M., Grant, F. and Thompson, P. (2010) Formative assessment: balancing educational effectiveness and resource efficiency, *Journal for Education in the Built Environment*, 5(2), pp. 4-24.

Higher Education Academy (2011) *The UK Professional Standards Framework for teaching and supporting learning in higher education* [Online]. Available at: http://www.heacademy.ac.uk/assets/documents/ukpsf/ukpsf.pdf (Accessed: 9 April 2013).

Hounsell. D. (2009) The evaluation of teaching, in Fry, H., Ketteridge, S., Marshall, S. *A handbook for teaching and learning in higher education: enhancing academic practice*, 3rd ed. New York; London: Routledge. pp. 200-212.

Hussey, T. and Smith, P. (2002) The trouble with learning outcomes, *Active Learning in Higher Education,* 3(3), pp. 220-233.

JISC (2009) *Effective practice in a digital age* [Online]. Available at: http://www.jisc.ac.uk/media/documents/publications/effectivepracticedigitalage.pdf (Accessed: 30 July 2013).

Lawrence, J. (2005) Addressing diversity in higher education: Two models for facilitating student engagement and mastery, in *Higher education in a changing world, Proceedings of the 28th HERDSA Annual Conference*, Sydney, 3-6 July 2005, pp. 243-252.

Maher, A. (2004) *Learning Outcomes in Higher Education: Implications for Curriculum Design and Student Learning,* Journal of Hospitality, Leisure, Sport and Tourism Education, 3(2), pp. 46-54.

Moon, J. (2006) Linking levels, learning outcomes and assessment criteria – EHEA version, University of Bournemouth, UK [Online]. Available at: http://spectare.ucl.slu.se/adm/sus/2008/plagiarism_eng/JennyMoonExercise.pdf (Accessed: 24 July 2013).

National Committee of Inquiry into Higher Education (1997) *Higher Education in the Learning Society* [Online]. Available at: https://bei.leeds.ac.uk/Partners/NCIHE/ (Accessed 30 July 2013).

Price, M. , Carroll, J. , O'Donovan, B. and Rust, C. (2011) If I was going there I wouldn't start from here: a critical commentary on current assessment practice, *Assessment & Evaluation in Higher Education*, 36(4), pp. 479-492.

Price, M. and Rust, C. (1999) The experience of introducing a common criteria assessment grid across an academic department, *Quality in Higher Education*, 5(2), pp. 133–44.

Quality Assurance Agency (2007) *Subject benchmark statements: Chemistry* [Online]. Available at: http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/chemistryfinal.pdf (Accessed: 23 July 2013).

Royal Society of Chemistry (2012) *RSC Accreditation of Degree Programmes* [Online]. Available at: http://www.rsc.org/images/Accreditation%20Criteria%20January%202012_tcm18-151306.pdf (Accessed: 9 April 2013).

Rust, C. (2002) The impact of assessment on student learning, *Active Learning in Higher Education*, 3(2), pp. 145-158.

Ryan, B. and Dunne, J. (2011) Integrating formative feedback into individual and group assessments in a First Year Organic Chemistry Module, in *Proceedings of Edulear: 3rd Annual International Conference on Education and New Learning Technologies*, Barcelona, Spain, pp.4507-4515.

Sandhu, S., Afifi, T.O. and Amara, F.M. (2012) Theories and practical steps for delivering effective lectures, *Journal of Community Medicine and Health Education*, 2(6), 1000158.

Scattergood J. (2008) *Writing Learning Outcomes at Programme and Module Levels*, Dublin: Trinity College Bologna Desk.

Scott, I. (2011) *The Learning Outcome in Higher Education: Time to Think Again?* Worcester Journal of Learning and Teaching.

Southern England Consortium for Credit Accumulation and Transfer (2010) *SEEC credit level descriptors for Higher Education* [Online]. Available at: http://www.seec.org.uk/sites/seec.org.uk/files/SEEC%20Level%20Descriptors%202010.pdf (Accessed: 30 July 2013).

Toohey, S. (1999) *Designing courses for higher education*, Buckingham: The Society for Research in Higher Education & Open University Press.

Williams, N.A., Bland W. and Christie, C. (2008) Improving student achievement and satisfaction by adopting a blended learning approach to inorganic chemistry, *Chemistry Education Research and Practice*, 9, pp. 43-50.

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