Facilitating Formative Assessment Through Learning Paths Extracted From a Logical Structure of Intended Learning Outcomes

Preecha Tangworakitthaworn,
Lester Gilbert, and Gary B Wills
University of Southampton
pt2e10, lg3, gbw@ecs.soton.ac.uk

Abstract

This paper argues that facilitating learners with suggested learning paths extracted from a logical structure of intended learning outcomes, enables learners not only to achieve their learning goals but also to support formative assessment and self-directed learning. The paper explores the issue of applying outcome-based education to assessment, and using intended learning outcome to support formative assessment and self-directed learning. The proposed logical structure of intended learning outcomes and learning paths extraction are introduced and exemplified. Finally, formative assessment facilitating learners through suggested learning paths is proposed and discussed.

Introduction

Formative assessment offers individual learning opportunities to improve the learner's ability and competency. Traditionally, formative assessment takes place during the ongoing learning environment (or class room). Continuous monitoring of a learner's progress and providing feedback is an integral part of this approach. Formative assessment supports learners by providing information that they can use for improving their acquired skills.

In a learning environment, suggesting learning activities to learners supports their competency development as well as initiating self-directed learning. In order to focus on what learners should achieve, an outcome-based education approach has arisen to focus on the results of educational activities defined in terms of what learners will be able to do after performing these activities. Specifically, intended learning outcomes play a crucial role in defining the learning objectives in which the learner's capability and learning materials (or subject matter contents) are expressed. This paper introduces the design of

a logical structure of intended learning outcomes (called an ILO diagram), and associated learning paths which are extracted from an ILO diagram, to be used in formative assessment.

This paper is structured as follows: First, we explore the application of outcome-based education to assessment through constructive alignment. In the next section, using intended learning outcomes to facilitate formative assessment and self-directed learning is introduced. We present the proposed design of a conceptual model of intended learning outcomes and learning paths extraction. Then, we present a scenario where the proposed approach to course delivery and formative assessment is applied. Finally, some conclusions are drawn.

Applying Outcome-Based Education to Assessment

Outcome-based education (OBE) is a pedagogic approach which defines educational activities in terms of what the learners should achieve by the end of the course, module, or programme (Anderson, 2005, Bouslama, 2003, Spady, 1991). This approach starts from the abstraction of the essential subject matter that learners should learn, then organises the curriculum, instruction, and assessment to ensure that the learning activities conform to the learning outcomes (Adedoyin, 2010). The term "*outcome*" in this sense is the clear and observable demonstration of learning that exists after learners undertake their learning experiences (Spady, 1994, Bouslama, 2003).

Bouslama et al. (2003) state that "learning outcomes are used at all stages of the students' academic life". In addition, learning outcomes encourage educators to pay attention to the complete content of the curriculum and its structure (e.g., lessons, units, courses, and programme) in order to determine what is essential for learners to achieve a high level of performance (Spady, 1991). Furthermore, Harden et al. (1999) state that learning outcomes present an effective and attractive approach for reforming and managing education. Applying learning outcomes in higher education is increasingly undertaken in curriculum planning (Otter, 1995).

Learning Outcome and Assessment

Fundamentally, there are two main categories of learning outcome: *intended learning outcome*, and *actual (or emergent) learning outcome* (Anderson, 2005, Alexander, 1999). The intended learning outcome is desired (or planned) before involving the learners in the learning environment (Anderson, 2005, Harden, 2002), whilst the actual learning outcome is the achievement of the learners after assessing the learning activities (Anderson, 2005).

In order to apply learning outcomes to assessment, Biggs (2003) originally introduced the *constructive alignment* approach. Biggs states that constructive alignment concerns "all components in the teaching system: the curriculum and its intended learning outcomes, the teaching methods, and the assessment tasks" (Biggs, 2003). Alignment ensures that the learning tasks (and assessments) are suitable for and appropriate to the intended learning outcomes, and cover both the teaching methods and the assessments which are to be aligned (Biggs, 2003). There are four steps of constructive alignment, as illustrated in Figure 1.

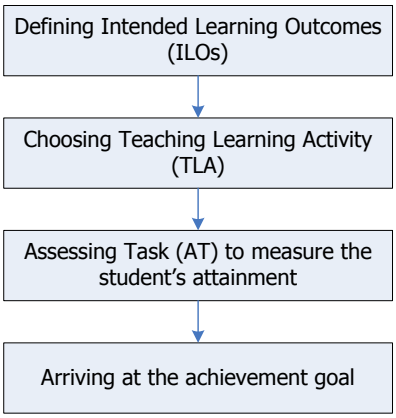

Figure 1 Four steps of constructive alignment summarised from Biggs (2003)

A course of study is described as being constructively aligned when it meets four criteria: ILOs are clearly specified, ILOs are explicitly communicated to the students, the assessments match ILOs, and the teaching activities match ILOs (Brabrand, 2008).

ILOs Support Formative Assessment and Self-Directed Learning

An intended learning outcome (ILO) is a planned (or desired) learning outcome which expresses the learner's ability to perform an activity by the end of the course module (Kennedy, 2007). Traditionally, an ILO states, "By the end of the course, the learner will be able to... X and Y", where X is a capability and Y is the subject matter content (Gilbert & Gale, 2008).

Implementing intended learning outcomes in formative assessment is a major component of constructive alignment, and assists instructors (or educators) to measure the development of the learners' competencies. Sadler (1989) states that "formative assessment is concerned with how judgments about the quality of learner responses (performances, pieces, or works) can be used to shape and improve the student's competence by short-circuiting the randomness and inefficiency of trial-and-error learning". Moreover, developing competence assists individuals in improving the performance of all stakeholders in education (Kalz, 2010). This approach is applicable to the pedagogical activities in order that the learning, teaching, and assessment of learners relates to the learning outcomes in order to enhance the performance (Hoffmann, 1999).

Furthermore, focusing on ILOs can support self-directed learning in higher education. ILOs lead learners to understand learning content and learning materials. Applying ILOs in education supports learners in taking more responsibility for their own learning (Harden, 1999). Harden (1999) also states that an ILO approach "provides students with a clear framework which allows them to plan their studies and to gauge their progress through the curriculum".

Proposed Approach

This research proposes a logical structure of ILOs in a conceptual model called an ILO diagram (Tangworakitthaworn, 2013). An ILO diagram can effectively guide instructional designers in planning the learning objectives for course modules.

A Conceptual Model of Intended Learning Outcomes

An ILO statement expressed in plain text is the basis of an ILO node in an ILO diagram. Structurally, each ILO node consists of four elements: ILO identifier, two dimensional performance/content matrix (2D-PCM), learned capability verb (LCV), and subject matter content (SMC). The ILO identifier is a number which identifies the node in an ILO diagram. The 2D-PCM element represents the classification of the ILO node within a two dimensional performance/content matrix (Merrill, 1994; Tangworakitthaworn, 2013). The SMC element represents the learning content of the ILO, and it is used to show relationships between ILOs with matching or similar SMCs. The LCV element represents the capability element of the ILO node and is used in two ways. First, it is mapped to a cognitive hierarchy (such as that of Bloom, 1956) as illustrated in Figure 2. Second, and more significantly, enabling ILOs are related to higher-level ILOs through consideration of the LCV (called LCV mapping). The detailed design of an ILO diagram and the notational conventions of the ILO diagram are presented in Tangworakitthaworn (2013).

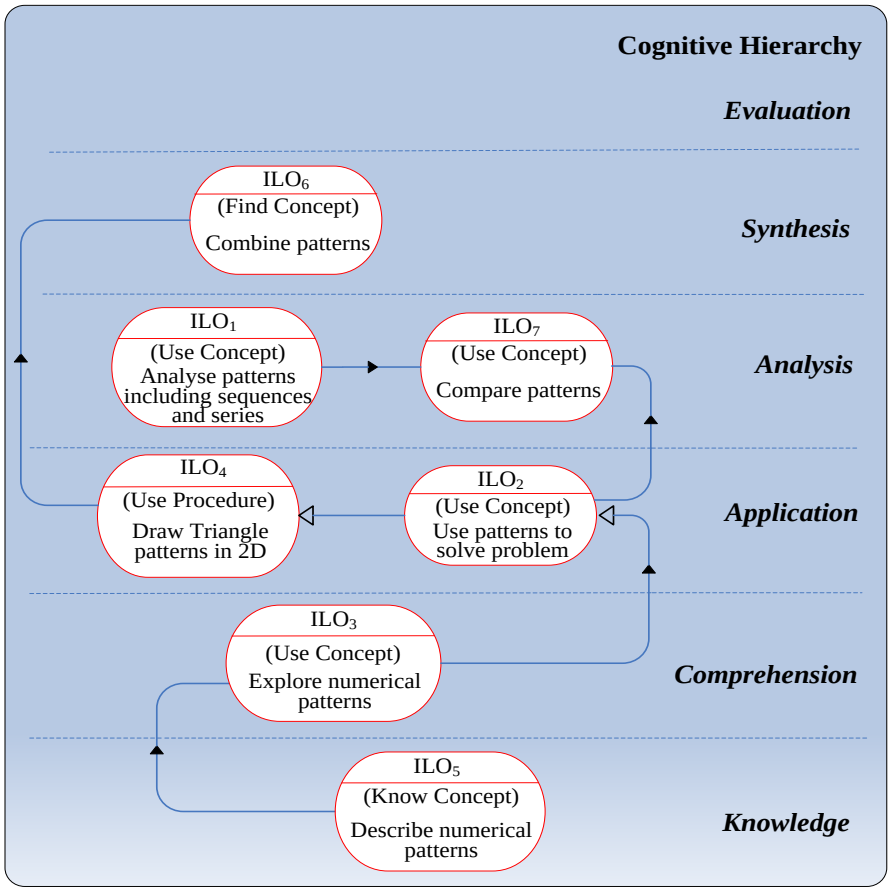

Figure 2 An ILO Diagram of a module to teach Pascal's Triangle

An ILO diagram is structured using a cognitive hierarchy such as one based on Bloom's taxonomy of the cognitive domain (Bloom, 1956). Figure 2 illustrates an example ILO diagram of a module to teach Pascal's Triangle (a number pattern in mathematics) (HMSO-QCA, 1999).

Learning Paths Extraction

Extracting and expressing learning paths from an ILO diagram represents appropriate sequences of pedagogical activities.

A learning path (LP) is a sequence of ILOs $\{ILO_1, ILO_2,..., ILO_n\}$ such that $\{(ILO_1, ILO_2), (ILO_2, ILO_3),... (ILO_{n-1}, ILO_n)\}$ are relations on the ILOs called *edges*. Two ILOs are connected if there is a path (or edge) leading from one to the other. Thus, an edge is an order pair (ILO_i, ILO_j); i is the start and j is the end of an edge.

If ILO_i and ILO_j are two ILO nodes, and an order pair (ILO_i, ILO_j) is an edge between these two ILOs, we say that a learning path LP goes from ILO_i to ILO_j, that is, $LP = ILO_i \rightarrow ILO_j$.

Table 1 Example of learning paths

LP No.	Learning Paths
LP_1	$ILO_5 \rightarrow ILO_3$
LP_2	$ILO_2 \rightarrow ILO_3$
LP_3	$ILO_5 \rightarrow ILO_4$
LP_4	$ILO_3 \rightarrow ILO_1$
LP_5	$ILO_5 \rightarrow ILO_4 \rightarrow ILO_6$
LP_6	$ILO_5 \rightarrow ILO_3 \rightarrow ILO_2 \rightarrow ILO_4$

Table 1 illustrates six learning paths extracted from an ILO diagram depicted in Figure 2.

Towards Formative Assessment through Suggested Learning Paths

The learning paths extracted from an ILO diagram can suggest an appropriate sequence of learning activities. In order to apply the suggested learning paths in formative assessment, we analyse the course delivery from two perspectives: learner's and instructor's. Figure 3 illustrates a UML use case diagram to systematise the processes of course delivery based on applying ILOs, the corresponding ILO diagram, and derived learning paths as facilitators in teaching and learning.

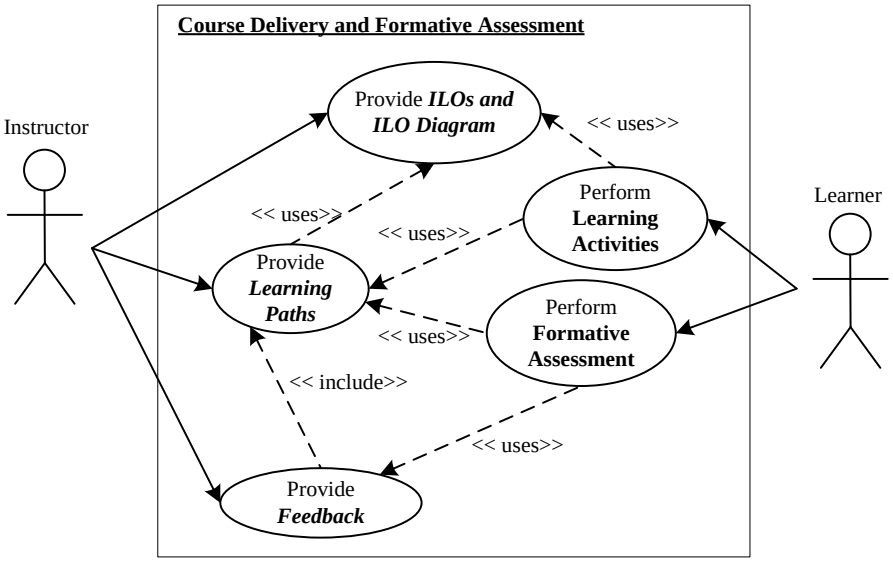

Figure 3 Use case diagram for course delivery and formative assessment

First, there are three main use cases of course delivery assigned to an instructor. "Provide ILOs and an ILO diagram" is the first use case. An instructor can utilise all ILOs expressed in plain text and visualised through an ILO diagram to facilitate teaching. The second use case is to provide learning paths extracted from an ILO diagram to the learner. Such paths suggest the appropriate learning activities that the learner should perform in order to achieve their learning goals. Finally, an instructor provides feedback and suggestions to the learner on the outcome of their learning activities.

Second, for the learner, two main use cases are assigned which are to perform learning activities and to perform formative assessment. In the learning environment (or class room), the learner refers to ILOs while the learning activity is ongoing. He/she can take advantage of ILOs expressed in both plain text and visualised through an ILO diagram to facilitate their performance. In addition, the learner undertakes formative assessment and receives feedback from the instructor.

From "*A Conversational Framework for Individual Learning"* proposed by Laurillard (Laurillard, 1999, Laurillard, 2002), we adapted the interactive dialogue of the conversational framework to introduce an algorithm for "*learner*" that addresses the issue of applying ILOs in formative assessment. The following algorithm, consistent with the conversational framework, is designed for learners to perform learning activities and formative assessments within the proposed scenario depicted in Figure 3:

Learner's Conception Phase:

[Step 1] Understanding Ideas: a learner understands the course outline, learning content, and learning materials by referring to 1) all ILOs expressed in plain text and 2) an ILO diagram.

[Step 2] Transferring Conceptions: a learner interacts with the instructor in order to acknowledge his/her conceptions.

[Step 3] Re-description: a learner and instructor exchange ideas and conceptions to achieve a clearer understanding.

Learner's Actions Phase:

[Step 4] Taking Actions: a learner performs the learning activities by referring to 1) all ILOs expressed in plain text, 2) an ILO diagram, and 3) the suggested learning paths, as facilitators.

[Step 5] Realising Feedback: a learner realises the feedback provided by instructor.

[Step 6] Modified Actions: a learner performs the modified actions after understanding the feedback and adjusting the learning activities.

[Step 7] Taking Formative Assessment: a learner measures the results of learning activities by observing his/her learned capability from the completeness score calculated from his/her learning paths.

[Step 8] Learner's Adaptation: a learner adapts his/her conceptions in learning contexts, learning goals, and feedback.

Practically, this algorithm extends Laurillard 's conversational framework in step 7, in which the formative assessment has been assigned to measure the results of learning activities. Moreover, self-directed learning will be initiated through step 4 to step 8.

Conclusions

This paper introduces an alternative approach to facilitate learners in undertaking learning activities and formative assessment with suggested learning paths extracted from an ILO diagram. Based on a logical structure of ILOs visualised through the proposed ILO diagram, learning paths can represent an appropriate sequence of pedagogical activities.

In the proposed scenario of course delivery, a learner can utilise 1) all ILOs expressed in plain text, 2) a logical structure of all ILOs visualised through an ILO diagram, and 3) the suggested learning paths extracted from an ILO diagram, as facilitators in performing the learning and formative assessment. Moreover, the proposed algorithm of learning based on Laurillard's conversational framework has been introduced to systematise the learning processes. Within this algorithm, the formative assessment is an extended step of the conversational framework. Furthermore, self-directed learning can be initiated within this system.

References

Adedoyin, O. O. and Shangogoyin, D. K. (2010). *Concepts and Practices of Outcome Based Education for Effective Educational System in Botswana*. European Journal of Social Sciences, 13(2)**,** 161-170.

Alexander, S. (1999). *An Evaluation of Innovative Projects Involving Communication and Information Technology in Higher Education*. Higher Education Research & Development 18(2)**,** 173-183.

Anderson, H. M., Moore, D. L., Anaya, G., and Bird, E. (2005). Student Learning Outcomes Assessment: A Component of Program Assessment. *American Journal of Pharmaceutical Education,* 69(2)**,** 256-268.

Biggs, J. (2003). Aligning Teaching for Constructing Learning. *The Higher Education Academy*. Available:http://www.bangor.ac.uk/adu/ the_scheme/documents/Biggs.pdf [Accessed 21 April 2013].

Bloom, B. S., Engelhart, M.D., Furst, E.J., Hill, W.H., and Krathwohl, D.R. (1956). *Taxonomy of Educational Objectives: Handbook 1 Cognitive Domain*, New York: David McKay.

Bouslama, F., Lansari, A., AI-Rawi, A., and Abonamah, A.A. (2003). A Novel Outcome-Based Educational Model and its Effect on Student Learning, Curriculum Development, and Assessment. *Journal of Information Technology Education*, 2**,** 203-214.

Brabrand, C. (2008). Constructive Alignment for Teaching Model-Based Design for Concurrency (A Case-Study on Implementing Alignment in Computer Science). In Transactions on Petri Nets and Other Models of Concurrency 5100/2008, 1-18.

*Brindley, G. (2001). Outcomes-Based Assessment in Practice: Some Examples and Emerging Insights. Language Testing, 18(4)**,** 393-407.*

Gilbert, L. and Gale, V. (2008). *Principles of E-Learning Systems Engineering*, Oxford, UK: Chandos Publishing.

Harden, R. M. (2002). *Learning Outcomes and Instructional Objectivies: is there a difference?*, Medical Teacher, 24(2)**,** 151-155.

Harden, R. M., Crosby, J. R. and Davis, M. H. (1999). *AMEE Guide No.14: Outcome-Based Education: Part1--An Introduction to Outcome-Based Education*, Medical Teacher, 21(1)**,** 7-14.

Harlen, W. and James, M. (1997). *Assessment and Learning: Differences and Relationships between Formative and Summative Assessment*, Assessment in Education, 4(3)**,** 365-379.

HMSO-QCA. (1999). *Mathematics: The National Curriculum for England (Key Stages 1-4).* Available: https://www.education.gov.uk/publications/standard/publicationDetail/Page1/QCA-99-460 [Accessed 20/03/2013].

Hoffmann, T. (1999). The Meanings of Competency. *Journal of European Industrial Training*, 23(6)**,** 275-286.

Kalz, M., Specht, M., Nadolski, R., Bastiaens, Y., Leirs, N., and Pawlowski, J. (2010). *OpenScout: Competence Based Management Education with Community-Improved Open Educational Resources*. 17th EDINEB Conference Crossing Borders in Education and Work-Based Learning**,** 137-146.

Kennedy, D., Hyland, A. and Ryan, N. (2007). *Writing and Using Learning Outcomes: a Practical Guide*: University College Cork.

Laurillard, D. (1999). A Conversational Framework for Individual Learning Applied to the 'Learning Organisation' and the 'Learning Society'. *Systems Research and Behavioral Science*, 16**,** 113-122.

Laurillard, D. (2002). *Rethinking Teaching for the Knowledge Society.* EDUCAUSE Review, 37(1)**,** 16-25.

Merrill, M. D. (1994). *The Descriptive Component Display Theory*. In: Twitchell, D. G. (ed.) Instructional Design Theory. New Jersey: Educational Technology Publications,111-157.

Otter, S. (1995). *Learning Outcomes in Higher Education.* In: Burke, J. (ed.) Outcomes, Learning and the Curriculum: Implications for NVQs, GNVQs and Other Qualifications. London: Falmer Press,273-284.

Rushton, A. (2005). Formative Assessment: A Key to Deep Learning? Medical Teacher, 27(6), 509-513.

Sadler, R. (1989). Formative Assessment and the Design of Instructional Systems. *Instructional Science*, 18**,** 119-144.

Spady, W. G. and Marshall, K. J. (1991). Beyond Traditional Outcome-Based Education. *Educational Leadership*, 49(2)**,** 67-72.

Spady, W. G. and Marshall, K. J. (1994). Light, not Heat, on OBE. *The American School Board Journal*, 181**,** 29-33.

Tangworakitthaworn, P., Gilbert, L. and Wills, G. B. (2013). *Designing and Diagraming an Intended Learning Outcome Structure: A Case Study from the Instructors' Perspective*. The 13th IEEE International Conference on Advanced Learning Technologies (ICALT2013), Beijing, China.