



Course Design

Considerations for trainers

PROFESSIONAL GUIDE

Course design

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Overview

This Professional Guide introduces a structured approach to course design, highlighting the importance of articulating learning outcomes commensurate with the cognitive complexity of the target learning, prior to devising learning experiences and course content. The specific focus here is on face-to-face activities, but the guidance is also relevant for those designing online courses.

Teaching Goals & Learning Outcomes

This Guide outlines a series of steps that can help trainers to devise and deploy effective courses. On reading this Guide, and engaging with the reflective exercises, you will be able to:

- *list* five key phases of curriculum & course development;
- *explain* the primary role of learning outcomes;
- *write* learning outcomes for a course;
- *identify* the Bloom's-level accomplishments that different types of learning experience are likely to support;
- *describe* the role of learning outcomes in selecting relevant content;
- *distinguish* different types of assessment & their role in supporting learner progression towards learning outcomes; and
- *summarise* the benefits of course evaluation.

1 Introduction

Teaching and **training**, core elements of academic life, can be enormously rewarding but also quite challenging. Instructors are often required to perform under various constraints, and frequently have to accommodate, engage and motivate student cohorts with very different backgrounds and aptitudes in limited time-frames. This can be daunting for experienced teachers, but especially so for those who're relatively new to teaching and training.

Formal education enterprises generally begin with **curriculum**¹ design: this involves specifying i) its purpose or **Teaching Goals (TGs)**; ii) its duration; iii) the Knowledge, Skills and Abilities (**KSAs**) intended to be achieved, expressed as a set of **Learning Outcomes (LOs)**; iv) how learners will demonstrate achievement of those LOs; v) the materials, **Learning Experiences (LEs)** and assignments instructors will use to support learner progression towards the LOs; and vi) the assessments for evaluating student learning and teaching effectiveness. Emphasis is placed on teaching *and* learning, and mechanisms for collecting evidence that learners have *changed over time*². In this latter sense, the concept of 'curriculum' differentiates formal teaching from *training*, as formal programmes usually afford time for learners both to be able to progress and to *demonstrate their progression*.

By contrast, training courses are much shorter (measured in days or weeks, rather than years); they hence necessarily focus on acquiring specific KSAs in limited time-frames, generally without consideration of learner progression beyond the course. However, the essential features of *effective curricula* (i.e., those that achieve their stated LOs for the majority of learners) pertain to instruction on *any* time-scale; they are thus also relevant for short courses, and provide important considerations for those involved in, or embarking upon, course design (whether face-to-face or online).

With this in mind, this Guide outlines key steps of curriculum development – and the role of Bloom's taxonomy³ – that can be

used to inform the design of effective courses. The Guide is based on *Guidelines for curriculum and course development in higher education and training* by Tractenberg *et al.*², and is the first of the GOBLET-ELIXIR resources for training trainers.

2 About this Guide

This Guide provides an overview of five design phases that facilitate course design. Exercises and Reflections are provided to help readers consider how to incorporate the concepts discussed here into their everyday practices. Throughout the text, key terms – rendered in **bold** type – are defined in boxes. Additional information is provided in supplementary boxes and figures.

KEY TERMS

Curriculum: the inventory of tasks involving the design, organisation & planning of an education or training enterprise, including specification of learning outcomes, content, materials & assessments, & arrangements for training teachers & trainers

Learning Outcomes (LOs): the KSAs that learners should be able to demonstrate after instruction, the tangible evidence that the **teaching goals** have been achieved; LOs are *learner-centric*

Learning Experience (LE): any setting or interaction in or via which learning takes place: *e.g.*, a lecture, game, exercise, role-play, *etc.*

Teaching: usually, instruction delivered over long time-scales via a series of courses (in schools, colleges, universities, *etc.*) designed to contribute to a formal programme that, if completed successfully, yields an accredited qualification in a given field (*e.g.*, a degree)

Teaching Goal (TG): the intentions of an instructor regarding the purpose of a curriculum/course/lesson/activity/set of materials; TGs are *instructor-centric* (also termed instructional objectives)

Training: instruction delivered via short courses designed to expand or build knowledge & practical skills in a given field, often conducted in the workplace or training centre to 'up-skill' members of a workforce

3 Formal curriculum design

3.1 Different types of curriculum

To set the scene for our considerations of course design, we examine some of the foundations for effective curriculum development, drawing heavily on the curriculum- and course-development guidelines developed by Tractenberg *et al.*². Notable here is the fact that different types of curriculum have been defined: *i.e.*, **intended**, **implemented**, **attained** and **hidden curricula**^{4,5}. Recognising the existence of different curriculum types (or, perhaps, different curricular outcomes) is important because, while the *intended* curriculum is the starting point, it may not be the curriculum actually *attained*: *i.e.*, what you aimed to teach and what students actually learned may not be the same.

To improve outcomes, differences between the intended and attained curricula need to be minimised. The only way to discover the attained curriculum is to find out what learning actually occurred. This requires **actionable** evaluation, to assess whether the TGs and LOs were achieved, to identify weaknesses in the implementation and to highlight improvements needed to remediate them. These considerations are key to developing effective curricula and courses.

3.2 Structuring curriculum design

Curriculum design benefits from being systematic: structured approaches help to orchestrate and clarify what will be taught, *why it will be taught* and how; they also afford opportunities to evaluate what does and doesn't work, and hence what needs to change, ultimately leading to improvements in learning outcomes^{6,7,8}. Several different frameworks have been devised to facilitate the design process, but each is motivated by the same underlying philosophy: to help formulate programmes that promote *meaningful and enduring learning*. If we're to understand whether we've really achieved this, we must i) determine the purpose of the programme (what needs it addresses, why it's being developed, what learners will gain from it, why it's important), ii) define the intended LOs, and iii) develop **assessment** and evaluation mechanisms that will allow us to measure whether the programme successfully met its goals.

Not surprisingly, the same principles apply to course design. The process may seem daunting, but for the sake of simplicity, we focus here on one model: *i.e.*, that proposed by Nicholls⁹. Before discussing this further, however, it's helpful to consider another very important tool used in teaching and learning – Bloom's taxonomy³.

Bloom's taxonomy of cognitive complexity

Learning taxonomies are useful tools that can help both to formulate and clarify LOs, and to arrange them on a scale of increasing complexity. Bloom's taxonomy³, probably the most easily understood and widely used today, features a *six-level hierarchy of cognitive complexity*, ranging from **Remember** (being able to recall facts and basic concepts) to **Evaluate** (being able to defend opinions or decisions), as illustrated in **Figure 1**.

As can be seen from the Figure, each Bloom's level is accompanied by a set of active verbs that express expected, measurable learner behaviours at that level: *e.g.*, achieving the level **Understand** means to be able to classify, select or explain a piece of information: here, *classify*, *select*, *explain* are observable, assessable behaviours that can be readily encapsulated in coherent LOs (more details on Bloom's assessable or active verbs are given in other Guides from the *Professional Guide* series).

Typical illustrations of the taxonomy, like that in **Figure 1**, depict successive cognitive levels, suggesting that learners must achieve

one level before advancing to the next, implying a *developmental trajectory* from lower- to higher-order cognitive skills. However, this structure shouldn't be regarded as completely rigid; indeed, Anderson *et al.*¹⁰ published a revised version in 2001 in which they placed **Synthesise** (the ability to create new or original work) at the top of the hierarchy in place of **Evaluate**. Notwithstanding the minutiae, it is perhaps more fruitful to regard the taxonomy as a continuum or spectrum of cognitive levels, where each merges into the next, providing a structured tool to help express measurable, assessable LOs, in which the cognitive levels are made explicit.

The cognitive aspects embodied in LOs are important. Teaching should promote more complex behaviours than just *recall* or *recognition* (unless remembering is the intended LO), and push learners to achieve greater cognitive complexity^{8,12-15}. This can be done by embedding *development* in learning activities and materials, and ensuring that LOs reflect the lowest to the highest levels of cognitive complexity *realistically achievable* on completing those activities or having engaged with those materials (*realistic* aims are key, especially for short courses: *e.g.*, expecting learners with no prior subject knowledge to achieve the level **Evaluate**, say in a 1-day course, will guarantee failure and frustration for learners and instructors alike).

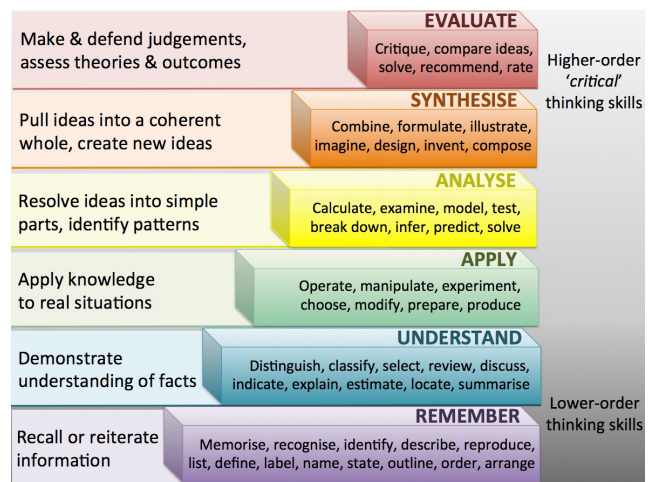


Figure 1. Bloom's taxonomy of cognitive complexity, & a sample of associated verbs that can be used to create LOs. The verbs reflect a developmental trajectory, from lower- to higher-order thinking skills; they should be concretely observable & relate to how achievement of target LOs will be assessed.

KEY TERMS

- Actionable:** supportive of a decision, or the taking of some action by a learner, instructor or institution
- Assessment:** the evaluation or estimation of the nature, quality or ability of someone or something
- Attained curriculum:** what learners actually acquire & can demonstrate having followed the implemented curriculum
- Hidden curriculum:** unintended curricular effects: unofficial norms, behaviours & values that are transferred (not necessarily consciously) by the school culture or ethos; this recognises that schooling happens in broad social & cultural environments that influence learning
- Implemented curriculum:** or taught curriculum, how the intended curriculum is delivered in practice: *i.e.*, the teaching & learning activities, & the interactions between learners & teachers, & among learners
- Intended curriculum:** the formal specification of KSAs that students are expected to achieve & be able to demonstrate having followed the implemented curriculum

4 Nicholls' five phases of curriculum design

The backdrop for our considerations of course design is Nicholls' paradigm for curriculum development, illustrated in **Figure 2**. Its five-phase structure has been briefly summarised by Tractenberg *et al.*², as follows:

1. Select LOs;
2. Select or develop LEs that will help learners achieve the LOs;
3. Select or develop content relevant to LOs;
4. Develop assessments to ensure learners progress toward LOs;
5. Evaluate the effectiveness of LEs for leading learners to LOs.

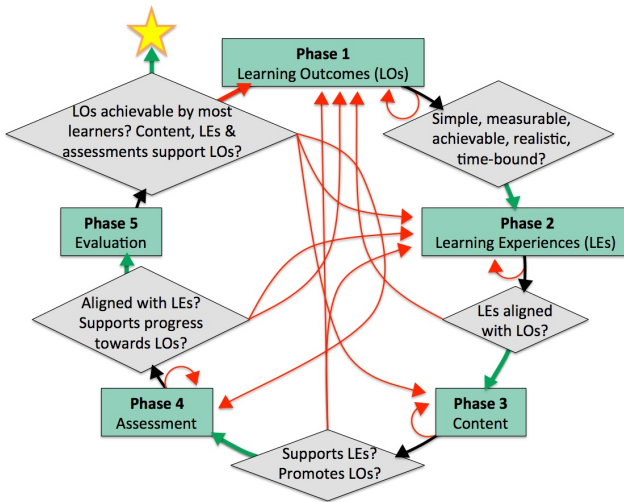


Figure 2. Nicholls' phases of curriculum design & their dependencies. For each phase, key considerations are shown (diamonds). Where these aren't satisfied, that or previous phases should be revisited (red arrows), otherwise it is safe to move to the next phase(s) (green arrows). When all considerations are satisfied, the curriculum or course can be characterised, with concrete evidence, as successful (star).

As can be seen from **Figure 2**, the model's phases are interdependent; all are ultimately dependent on the first – defining LOs. Moreover, the phases are iterative: this means that LOs influence later decisions, but later decisions may also reflect backwards, thereby providing opportunities to check for alignment of each phase to the target LOs (in other words, to ensure that successive phases are mutually consistent with, and supportive of, the LOs). Thus, the role of LOs is pivotal: they must have specific characteristics to function, and support each of the other phases as they do.

Figure 2 illuminates an important feature of the model: that *LOs are the starting point, and drive all decision-making*. This is just as true for courses as it is for programmes⁷. Missing from the model, however, is the dependence of LOs on a hierarchy of cognitive complexity that establishes a developmental trajectory, like that seen in Bloom's taxonomy. We reflect on this crucial point, and its relevance for course design, in the discussion of each of the five phases below.

4.1 Define intended LOs

Just as for curricula, Phase 1 of course design begins with stating the LOs (as already noted, LOs are explicit statements of the KSAs – and requisite level of cognitive complexity – that learners are expected to achieve, and be able to demonstrate, on completion of a period of instruction). To help formulate LOs, it's important to take a step back and think about what you aim to achieve (*i.e.*, what are your TGs and the KSAs you intend to be achieved?), how you

propose to get there, and how you'll know you succeeded. Messick¹¹ encapsulated this process in the form of three succinct questions:

1. What KSAs are the targets of instruction (and assessment)?
2. What learner actions/behaviours will reveal these KSAs?
3. What tasks will elicit these specific actions or behaviours?

These questions were originally posed in 1994 in the context of assessment. Their focus on KSAs – the LOs – thus guides not only the creation of relevant tasks (to reveal the target KSAs) but also the rational development of *appropriate* assessments: *i.e.*, they provide a framework for, and clarify, *what to assess*. The questions can thus support all phases of course development, starting with the selection of intended KSAs stated in a set of LOs.

Writing coherent LOs is challenging: they must contain appropriate (Bloom's) verbs (**Figure 1**) that express measurable, observable and assessable actions, accurately describing what successful learners will be able to do – *and at what level of cognitive complexity* – after instruction.

Various characteristics of, and principles for articulating, LOs have been published^{16,17}: some of these are listed briefly in the box below (further information and additional guidance on how to write effective LOs is given in other Guides from the *Professional Guide* series). Given their detail and complexity, and the importance of aligning the instructional inputs you devise with the outcomes for learners you intend, it can be hard to know where to start. This possibly explains why it may feel easier to begin developing a course by selecting its content rather than first trying to understand its impact on student learning. Nevertheless, ensuring that target LOs meet, or are consistent with, the characteristics outlined in the box below helps to promote better alignment of instructional inputs and learner outcomes.

In short, when defining LOs, the key question to ask is, are they Specific, Measurable, Achievable, Realistic and Time-bound – *i.e.*, are they SMART? If they don't satisfy this test, they should be revised; only when they meet these criteria is it safe to progress to Phase 2, as shown in **Figure 2**. Ultimately, *LOs provide the necessary structure and context for decision-making by instructors (and learners), hence their primary role in course design*.

Learning outcomes

LOs should:

- **be specific & well defined:** LOs should concisely state the specific KSAs that learners should develop as a result of instruction;
- **be realistic:** LOs must be attainable given the context and resources available for instruction, and consistent with learners' abilities, developmental levels, prerequisite KSAs, and the time needed vs. time available to achieve them;
- **rely on active verbs, phrased in the future tense:** LOs should be stated in terms of what successful learners will be able to do as a result of instruction;
- **focus on learning products, not the learning process:** LOs should not state what instructors will do during instruction, but what learners will be able to do as result of instruction;
- **be simple, not compound:** LOs shouldn't include compound statements that join two or more KSAs into one statement;
- **be appropriate in number:** LOs should be deliverable and assessable within the time available for instruction;
- **support assessment that generates actionable evidence:** here, actionable means supportive of a decision, or taking some action by a learner or instructor.

EXERCISES

- 1 Think of a course you currently run, plan to run or have run in the past. Are its intended LOs stated? If not, try to jot a few down.
- 2 Now consider, are your LOs SMART? If any of them don't meet the SMART criteria, try revising them as follows: select an active verb that can (in principle) be observed & assessed, & complete the sentence, "At the end of this course, learners will be able to..." (if it helps, review the verbs listed in Figure 1). It's important to focus here on what learners will be able to do at the end of instruction: e.g., will they be able to describe its content? Explain a concept? Implement an algorithm? Solve a problem? Evaluate results?
- 3 To determine how well you've structured your LO, visit the Intended Learning Outcome Advisor: <https://web.cs.manchester.ac.uk/iloadvisor> & paste your phrase into the input box. Press the 'SUBMIT' button. How well did you do?
- 4 Consider revising your phrase if the Advisor identified any issues. Consider writing further LOs; test each using the Advisor.

4.2 Select LEs that will lead to the LOs

Phase 2 involves identifying the most appropriate LEs to lead learners to the intended LOs. It's important to appreciate that different LEs can lead learners to demonstrate different Bloom's-level accomplishments: e.g., lectures differ from problem-sets – solving problems helps learners to work with, and manipulate, information rather than passively listening to it; similarly, lab exercises differ from writing computer programs – writing original code affords learners the opportunity to create something new rather than simply following instructions. Some example LEs are listed in Table 1, together with the Bloom's level and the kinds of TG and LO that each may support.

Having defined SMART LOs in Phase 1, Phase 2 thus hinges on choosing the most appropriate LEs to best lead learners towards them: if LOs include, for example, being able to *write a computer program*, then the LEs must allow learners to apply the knowledge they've acquired and to demonstrate that they've written a piece of functional code: i.e., LEs and LOs must be aligned (if they aren't, this

Table 1 Sample learning experiences & the highest Bloom's level that each may support. Examples of the kinds of teaching goal that such LEs may underpin & the kinds of learning outcomes they may promote are also shown.

Learning experience	Highest Bloom's levels supported	Example TG(s) <i>This LE will allow me to...</i>	Example LO(s) <i>Learners will be able to...</i>
Lecture, webinar	Remember, Comprehend	Inspire learners, ignite learners' enthusiasm, clarify/explain a concept, provide an overview, give context, summarise content	<ul style="list-style-type: none"> • <i>list</i> the key points of the lecture/webinar • <i>summarise</i> take home message(s)
Exercise, practical	Apply, Analyse	Help learners digest course materials, solve typical problems, apply knowledge, show how to do things with appropriate guidance, give an idea of how a tool works	<ul style="list-style-type: none"> • <i>follow</i> a set of instructions or protocol • <i>calculate</i> a set of results or outcomes from a given protocol
Flipped class	Apply, Analyse	Teach learners how to formulate questions, help learners to memorise new information & concepts, or analyse & understand course materials	<ul style="list-style-type: none"> • <i>summarise</i> the content material • <i>ask</i> appropriate questions
Peer instruction	Synthesise, Evaluate	Prepare learners to defend an argument, give learners opportunities to explain things, thereby helping to develop critical thinking & awareness	<ul style="list-style-type: none"> • <i>explain</i> how they solved an exercise • <i>evaluate</i> others' choices/decisions • <i>diagnose</i> errors in the exercise-solving task
Group discussion	Synthesise, Evaluate	Give learners opportunities to practice questioning, develop new ideas & critical thinking	<ul style="list-style-type: none"> • <i>communicate</i> their own ideas • <i>defend</i> their own opinions
Group work	Synthesise, Evaluate	Promote collaborative work & peer instruction, provide opportunities for giving/receiving feedback, & digesting course materials	<ul style="list-style-type: none"> • <i>provide feedback</i> on their peers' work • <i>share</i> ideas • <i>explain the advantages of team-work</i>
Problem-solving	Synthesise, Evaluate	Promote learner abilities to identify & evaluate solutions, develop new ideas, make decisions, evaluate decision effectiveness, troubleshoot	<ul style="list-style-type: none"> • <i>diagnose</i> faulty reasoning or an underperforming result • <i>correct</i> errors

can lead directly to a gap between instructional inputs and intended outcomes, which is one reason why course evaluation to detect such misalignments is so crucial). If LEs don't satisfy this criterion, alternative LEs should be found, or the LOs should be revisited and revised before progressing to Phase 3 (as shown in Figure 2).

KEY TERMS

- Exercise:** an activity designed to help learners to mentally put into practice learned skills & knowledge
- Flipped class:** a learner-centred approach in which students are introduced to new topics prior to class; class time is then used to explore those topics in greater depth via interactive activities
- Group discussion:** an in-class, learner-centred approach in which students discuss ideas, solve problems &/or answer questions, guided by the instructor

- Group work:** a learner-centred approach in which students are organised into groups (& perhaps assigned specific roles) & are given tasks to perform collaboratively
- Lecture:** a didactic approach in which oral presentation is used to describe & explain concepts & to impart facts
- Peer-instruction:** an interactive, in-class, learner-centred approach in which groups of two or more students briefly discuss a question or assignment given by the instructor
- Practical:** an activity to put into practice learned skills & knowledge, generally in a lab setting
- Problem-solving:** a learner-centred approach in which students are required to systematically investigate a problem by building or determining the best strategy to solve it (using what is known to discover what is not known)
- Webinar:** a lecture delivered online

Sometimes, it may be necessary to use specific LEs: *e.g.*, if a course is lecture-based, it may not be possible to choose alternatives; or a particular teaching scenario may not allow for an ideal LE. Even if you're not in a position to select the most appropriate LEs, the LOs must still be consistent with the given LEs; and if those LEs won't help learners to achieve the LOs, then the LOs should be revised – *i.e.*, LOs are still the most important feature to consider. *The key is to determine exactly what specific LEs can contribute to learning or how they will help move learners towards the LOs.*

REFLECTIONS

- 1 Consider the LEs listed in Table 1.
- 2 Are any of these used in your course from the exercise above?
- 3 What kinds of achievement or learning are they most likely to promote? Is this consistent with your stated LOs?
- 4 Does your course have any LO that can't be achieved through the LEs that the course currently uses?

4.3 Select content relevant to the LOs

With LOs and LEs aligned, Phase 3 involves finding the most appropriate **content** to support learners to achieve the intended LOs. Regardless of where content is drawn from, what matters is how it supports the LOs. To this end, content selection should be judicious: it shouldn't try to be all-encompassing⁸, but should consider the target Bloom's levels in the LOs, and the preparation of learners. Once content that's considered to be the *core* of a course has been identified, additional *auxiliary* materials can also be selected, and offered, say, as 'further reading'. Using LOs to drive content selection in this way thereby both provides focus (avoiding the temptation to squeeze as much as possible into a course to ensure coverage^{18,19}), and increases the likelihood of accomplishing those LOs.

Sometimes, specific content may be deemed essential²⁰. Nevertheless, this must still support the LEs and promote achievement of the LOs; if it doesn't, then additional content and/or LEs should be considered that will, or the LOs themselves should be revised, to prevent misalignment of instructional inputs and learning outcomes. Overall, the role of *LOs here is to help focus on relevant content, and avoid material that's either non-essential/too broad or too narrow.*

REFLECTIONS

- 1 Think of a course you currently run, plan to run or have run in the past. Consider its content. How focused is it?
- 2 Is the content consistent with your LEs? Does it support your LOs?

EXERCISES

- 1 Consider a course you currently run, plan to run or have run in the past for which the intended LOs are stated. Review the LOs, & identify which parts of the course content support the LOs.
- 2 Map out the relationships between the LOs, the LEs via which they will be delivered & those specific items of content (*e.g.*, item A supports LO 1, & will be delivered using a lecture).
- 3 Is there any piece of content that doesn't support any LO(s)?
- 4 Is there at least one piece of content for each LO?
- 5 Is there at least one LE for each piece of content?

4.4 Develop assessments to ensure progression

In any course, learners benefit from having opportunities to show that they're progressing. Generally, this is done using various types of assessment, including tests, feedback surveys, and so on. Nicholls' model includes two different types of assessment, to evaluate

- i) **learning**, to detect changes in learner performance *during* instruction, to identify their strengths, and *diagnose* their weaknesses – *i.e.*, **formative assessment** (or feedback). This can inform decisions about how to modify instruction to better promote learning; it can also inform learners about changes *they may need to make* to improve their learning;
- ii) **instructional outcomes**, to verify whether learners achieved the stated LOs *after* instruction – *i.e.*, **summative assessment**. This can help to inform decisions both about learners (*e.g.*, ranking their performances) and about the course (*i.e.*, whether any of its LOs, LEs, *etc.* need to be redesigned).

Formative and summative assessments²¹ are important for determining *whether* and *what* learning has occurred. Summative assessment doesn't generally yield information about learners' *progress*: it sums up what learning has been achieved after instruction relative to the intended outcomes (via written tests, practical tasks, or other measurable activities), and gives valuable data about learning attainment at the level of individuals and entire learner cohorts. This can be tricky for short courses, but may be necessary for those that give credits or offer certificates of completion.

Formative assessments are applied throughout a course; planned thoughtfully, they can improve the performance of learners and instructors. Ideally, they should be used often (say, every 15-20 minutes), thereby also yielding opportunities to change pace and refocus learners' attention. It may be hard to conceive how to integrate such assessments into a course, but they need not be complex or time-consuming (just informative about learning at a given point) – see box on page 7 for some simple examples²².

If formative assessments are used frequently, and lead to specific decisions by learners and instructors, then instruction (or learner preparation) can be modified to better develop the target LOs^{23,24}. Such assessments can be designed to anticipate, and identify which learners are experiencing, common misunderstandings, and gauge their readiness to move ahead; they can also help learners to identify their own strengths and weaknesses by encouraging reflection on what they do/don't know or are/aren't confident about, honing their abilities to self-assess¹². Furthermore, ideas for how to address any issues they've found, or for further learning, can be built in (*e.g.*, "if you chose option C, you might want to re-read the handout"); formative assessments can therefore also support *self-instruction*.

Using actionable formative and summative assessment can help to ensure that LOs, and progress towards them, are explicitly supported. *LOs clarify what specifically needs to be assessed and why.*

REFLECTIONS

- 1 Think of a course you currently run, plan to run or have run in the past. Consider the assessments you use & how you assess learner progression. How much formative assessment do you use?
- 2 If you use summative assessment, does it paint a consistent picture of learning levels for your course? To what extent are your tests aligned with the KSAs & Bloom's levels expressed in the LOs?

KEY TERMS

- Content:** a specific subject or topic item (*e.g.*, DNA, RNA, proteins, a biochemical pathway, R programming) that is the target of learning
- Formative assessment:** formal or informal assessments (or feedback) made during learning so that instruction or practice can be better targeted for learners to be able to fully achieve target LOs
- Summative assessment:** assessments made after a period of instruction in order to monitor whether LOs have been achieved

Simple formative assessment strategies

The most effective way to test student understanding is to do so in class: it's important to seize the moment, and deal with potential misunderstandings as soon as they arise. These in-class tips may be helpful:

- **reflection:** towards the end of a training session, ask learners to reflect on, and write down, a list of new concepts and skills they've learned. Ask them to consider how they'd apply these concepts or skills in a practical setting;
- **agreed signals:** gauge learners' satisfaction with a training session by asking them to use agreed signals (e.g., raising coloured post-it notes to indicate that the pace is too fast/ slow, etc.). This engages all learners, and allows you to check their confidence with the content and its delivery, even in large groups;
- **3-2-1:** at the end of a training session, ask learners to note 3 things they learned, 2 things they want to know more about, and 1 question they have. This stimulates reflection on the session, and helps to process their learning;
- **misconception check:** present some common or predictable misconceptions about a concept you've covered. Ask learners whether they agree or disagree, and to explain why;
- **diagnostic questions/questionnaires (which may be anonymous):** ask learners to note one thing they didn't understand or that they missed, and one thing that was very clear to them, or make them complete a multiple choice quiz, then display and discuss the answers with them.

These, and many other simple assessments, may be found in Briggs' online list of *21 ways to check for student understanding*²².

EXERCISES

- 1 Consider the materials of the course you were just thinking about. Focus on a set of those materials corresponding to a single lesson.
- 2 Analyse the flow of the lesson, & identify points where you could introduce formative-feedback sessions.
- 3 For each portion of the lesson between two sets of feedback, imagine (& write down) a quick activity – an exercise, a question, a reflection – that learners could carry out that would help you understand whether they're following the lesson & that learning is occurring, or whether they're lagging behind or are lost.

4.5 Evaluate course effectiveness

The final step is to perform an *actionable evaluation* by collecting qualitative and quantitative course data to assess its effectiveness in leading learners to the stated LOs. Summative assessments can be useful here: e.g., if they reveal uniformly low levels of achievement, it may indicate that future revisions are needed to ensure that LEs, assessments and LOs are aligned; it could also flag problems with the assessment – it's vital to understand whether performance reflects student learning levels or issues with the assessment itself (poorly worded test questions, ambiguous response options, etc.), and, if not, to take steps to ensure that it does.

Even if a full quantitative course evaluation isn't possible, it may still be possible to solicit actionable evidence of its impact via short- or long-term feedback surveys. It's tempting to use completion rates or learner satisfaction as proxies for success; however, although simple to collate, these outcomes *aren't* informative about learners' growth or course effectiveness. Satisfaction surveys often use pre- and post-course questionnaires^{25,26} to collect demographic details, and solicit learners' self-evaluations and reactions to a course. Reviewing learners' perceptions can help to identify whether the

conditions for learning were present, but alone *will not* shed light on whether the intended LOs were achieved: learner perceptions may be affected by factors unrelated to course effectiveness, and their self-assessments may be biased (e.g., less-skilled learners notoriously overestimate their abilities – the Dunning-Kruger effect²⁷).

There are many evaluation methods, each with advantages and disadvantages; all concur that *multiple features* need to be considered. One framework collates learner reactions, their actual learning, changes in their behaviour, and the impact of the course on their organisation (see box below). Such features can be explicitly targeted in short- or long-term surveys: e.g., end-of-course, summative quizzes can be used to test achievement of intended LOs; longer-term questions (say, 6-12 months after a course) can focus on the extent to which learners have put their acquired KSAs into working practice; and so on. Overall, it's important to choose an appropriate evaluation method for your circumstances, and, alongside learner reactions to the course, for your evaluation to consider what results you expected to achieve, whether the LOs were achieved, and whether learners' on-the-job practices changed.

Methods to evaluate training effectiveness

Evaluation methods provide systematic frameworks for analysing the effectiveness of training courses. The first approach was introduced by Raymond Katzell in 1956 and later popularised by Kirkpatrick^{28,29}. The Kirkpatrick-Katzell method proposes a four-level strategy:

- **Level 1: Reaction** – what do learners feel about the training?
- **Level 2: Learning** – what did learners retain from the training?
- **Level 3: Behaviour** – did learners put their learning into practice on-the-job (did their working behaviour change)?
- **Level 4: Results** – did their behavioural changes have an overall impact on their organisation (e.g., greater productivity)?

Surveying each level helps collect qualitative and quantitative data to evaluate training effectiveness. Note: this isn't a real taxonomy, as there's no evidence that outcomes at successive levels are linked (e.g., no correlation has been found between the *reaction* and *learning* stages³⁰). However, if level 2 results indicate that learning didn't occur, those from level 1 may identify aspects of a course that disappointed learners and help understand what should be improved.

Many other approaches to training evaluation have been developed, each focusing on slightly different levels or stages³¹.

Actionable evaluation is essential for identifying aspects of a course that may benefit from intervention, leading to concrete decisions about what needs to be remediated and why³². Designing meaningful evaluations requires thought; in some cases, it may help to appoint independent evaluators or advisory boards, as external reviewers can give objective appraisals, and may also help to frame the course against national/international standards. *Ultimately, the evaluation should identify what works in a course, and what needs remediation, to better support the achievement of the intended LOs.*

REFLECTIONS

- 1 Think of a course you currently run, plan to run or have run in the past. Do you evaluate course effectiveness? If so, how do you do this? How do you determine its effectiveness in leading learners to your intended LOs?
- 2 Consider the Kirkpatrick-Katzell framework. What level(s) does your evaluation incorporate?
- 3 What adjustments would you need to make, if any, in order to align your evaluation with the Kirkpatrick-Katzell strategy?

5 Documenting and sharing

When developing a course, it's helpful to document the design process, including details of how it was conceptualised, the assumptions and decisions made along the way, the assessment criteria, etc., and to share that documentation with instructors and learners (this can be done via community mailing lists, through blog posts, collaborative repositories, social channels, using GitHub, Slack, etc.). By way of example, The Carpentries³³ provide instructor notes³⁴ for most of their courses. These are collectively-written documents that reflect on the strengths and weaknesses of the course design (and its materials), what did/didn't work, suggested improvements, tips for teaching, challenges encountered, learner feedback, and indications of where alignment of LOs/LEs/content/assessments failed, and why. Best practices like this help course designers and communities of trainers to understand what was intended, what was done, and why those might be different, if they are. This is particularly valuable for courses whose materials are not developed by its instructors. Such documentation can thus facilitate reflection and promote good practice, and can help new instructors prepare to deliver the course. If made available to learners, it can help them to understand what they can expect from a course, and make informed decisions about whether it will help them to achieve their learning goals; it may also help them to better gauge their performance, and to identify what will help them perform better – it may therefore also improve learning outcomes.

Creating and sharing documentation with instructors and learners fosters the development of communities of best practice, and can support both learning and the success of a course.

6 Conclusions

Course design is prefaced by determining the purpose of the programme, analysing the context in which the course will be delivered and who will benefit. Fundamental to this process is to identify the needs the course will address, its target audience, and the prerequisite KSAs that learners must have in order to profit most from the course. Identifying the target audience and learner prerequisites helps to define criteria for selecting participants, should a limit be needed to maximise course effectiveness.

Once such 'situational analysis' has been completed, the starting point, and pivotal reference for all subsequent stages of the course-design process, is to articulate SMART LOs. As part of this process, Bloom's taxonomy is useful for defining LOs that are measurable, and whose cognitive complexity increases along a developmental trajectory; and Messick's questions help both to select KSAs and LOs, and to ensure alignment of instruction and assessment. Crucially, informed choices need to be made about the LEs (and the content they use) that best align with the goal of achieving specific LOs *in the time available*. General topic areas (life sciences, computer science, data science, etc.) may provide the overarching framework, but *your goals for learners* should drive how content is selected, taught and assessed. In terms of assessment approaches, formative assessment is generally more relevant for short courses, but summative assessment may be necessary for accredited courses. Ultimately, it's important to understand what each type of assessment contributes to the course-design process and to build your practice to maximise the effectiveness of each.

Evaluating course effectiveness should be the final stage of a robust design process, and the first step towards course re-design and

improvement, should the course be delivered regularly. To do this rigorously, it's helpful to employ a multi-level evaluation strategy, in which learner satisfaction is just one strand (used alone, learner satisfaction is not a reliable metric of success).

Course design requires thought and time. Successful courses support learners as they develop from entry-level performance to the minimum performance level for achieving the target LOs. If designed specifically to support learners and LOs, and evaluated against that objective, the instruction that's delivered and learning that's intended are more likely to match. This can't guarantee success for all learners, but does create the optimal circumstances for success.

Structured approaches benefit course design by leveraging what's already known about learning, and providing a framework for decision-making. The process can be challenging, but investing in it is likely to pay dividends. Ultimately, everything in the design should lead to, and support development of, the LOs that learners should possess, and be able to demonstrate, on completion of a course.

For ease of reference, the approach outlined here can be distilled into the simple set of recommendations summarised in **Table 2**.

Table 2. Recommendations for supporting course design.

Recommendation	Benefits
1) Follow a structured paradigm for course design.	Leverages what's known about education & learning; provides a framework for decision-making.
2) Focus on LOs first, to inform all other course-design decisions.	LOs provide context for decision-making by instructors & learners.
2.1) Leverage LOs to determine appropriate LEs.	LOs help to choose LEs that support learners to achieve the LOs.
2.2) Leverage LOs to select content that promotes achievement of the LOs.	LOs help to focus on relevant content, & to avoid material that is non-essential &/or too narrow.
2.3) Assess learners' progress towards LOs & the achievement of LOs using formative & summative assessment, respectively.	LOs clarify what specifically needs to be assessed & why.
3) Plan & execute an actionable course evaluation.	Helps identify what works & what to remedy in the course to better support achievement of LOs.
4) Document & share the course features with learners.	Helps to support learning & promotes success of the course.

TAKE HOMES

- 1 Course development is a multi-step, iterative process;
- 2 The first step is to identify intended (SMART) LOs;
- 3 Identification of key content only becomes relevant after LOs & suitable LEs have been identified;
- 4 Bloom's taxonomy can facilitate the articulation of measurable LOs, & support the development of cognitive complexity through them;
- 5 Messick's questions help to align KSAs, instruction & assessment;
- 6 For successful outcomes, learners & the course must be evaluated (it isn't sufficient simply to note 'completers' or learner satisfaction);
- 7 A successful course guides learners from entry-level performance to the minimum performance level for achieving its target LOs;
- 8 In a course designed to support learners & LOs, the instruction that's delivered & learning that's intended are more likely to align, thereby providing the optimal circumstances for learner success.

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9 Licensing & availability

This Guide is freely accessible under creative commons licence CC-BY-SA 2.5. The contents may be re-used and adapted for education and training purposes.

The Guide is freely available for download via the GOBLET portal (www.mygoblet.org) and the F1000Research Bioinformatics Education and Training Collection (f1000research.com/collections/bioinformaticsedu?selectedDomain=documents).

10 Disclaimer

Every effort has been made to ensure the accuracy of this Guide; GOBLET cannot be held responsible for any errors/omissions it may contain, and cannot accept liability arising from reliance placed on the information herein.

About the organisations

GOBLET

GOBLET (Global Organisation for Bioinformatics Learning, Education & Training; www.mygoblet.org) was established in 2012 as a not-for-profit foundation to unite, inspire and equip bioinformatics trainers worldwide; its mission, to cultivate the global bioinformatics trainer community, set standards and provide high-quality resources to support learning, education and training. GOBLET's ethos embraces:

- **inclusivity:** welcoming all relevant organisations & people
- **sharing:** expertise, best practices, materials, resources
- **openness:** using Creative Commons Licences
- **innovation:** welcoming imaginative ideas & approaches
- **tolerance:** transcending national, political, cultural, social & disciplinary boundaries

For general enquiries, contact info@mygoblet.org.

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ELIXIR

ELIXIR is an intergovernmental organisation that brings together life science resources (databases, software tools, training courses, cloud storage, etc.) from across Europe. The aim is to create a single infrastructure, making it easier for scientists to find and share data, exchange expertise, and agree on best practices: elixir-europe.org.

Since 2015, the ELIXIR Training Platform and GOBLET have worked closely to promote and develop standards and best practices in bioinformatics training. Together, they have built a Train-the-Trainer (TtT) programme, which comprises a standard curriculum, associated training materials and well-trained instructors. To date, hundreds of scientists have benefited from this programme.

EMBnet

EMBnet, the Global Bioinformatics Network, is a non-profit organisation, founded in 1988 to establish and maintain bioinformatics services in Europe; today, it supports and delivers services across an international network: www.embnet.org. EMBnet has always had a keen interest in Education and Training (E&T), and has delivered tutorials and courses worldwide. Perceiving a need to unite and galvanise international E&T activities, EMBnet was a principal founder of GOBLET. For more information and general enquiries, contact info@embnet.org.



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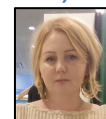
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