"At the end of my course, students should be able to …": The benefits of creating and using effective learning goals

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At the University of Colorado at Boulder (CU), several science departments – including Molecular, Cellular, and Developmental Biology (MCDB) – are working to improve undergraduate science education as part of the Science Education Initiative (SEI). The SEI is a 5-year project designed to support faculty-led, departmental-wide improvements in students' learning of and engagement in science [1]. In each of the five funded departments, faculty are taking a scholarly approach to transforming their courses and introducing proven teaching practices [2]. An important first step in course transformation has been to define explicit learning goals (also known as "learning outcomes" or "objectives") for each course. In this paper, we focus on the process and benefit of writing learning goals, with specific examples from CU's MCDB department.

Unlike a syllabus, learning goals do not merely list the topics to be covered. Instead they explicitly communicate the key ideas and the level at which students should understand them in operational terms [3, 4]. Learning goals take the form: "At the end of this course/lecture/unit, students will be able to ..." followed by a specific action verb and a task. For each course, faculty typically define five to ten course-level goals that convey the major learning themes and concepts, as well as topic-level learning goals that are more specific and aligned with the course-level learning goals. Figure 1 shows examples of learning goals from an introductory genetics course. A compilation of examples from the SEI efforts has also been developed [5].

Many faculty members have formed working groups to formulate learning goals. Those faculty members who have previously taught a course begin to write learning goals by sharing their syllabus, homework assignments, exams and other materials that demonstrate what they want students to be able to do. In addition, faculty members who teach subsequent courses communicate what they expect students to know coming into their course. These working groups typically include a facilitator whose role is to review and synthesise materials and create learning goal drafts. The members of the working group discuss and revise these learning goals until a consensus list is generated, which for any instructor teaching the course would typically cover 70% of the class time.

Based on our experiences with these working groups, we formulated a checklist to help ourselves and our colleagues create and critique learning goals (Figure 2). One of the most critical aspects of writing learning goals is choosing a verb that describes exactly what students should be able to do [3, 4]. Many faculty are tempted to use the verb "understand" such as: "students should understand how to do a genetic cross." However, "understand" is not specific – two faculty members could both say "understand" but have completely different expectations as to what students should be able to do. A more specific learning goal is: "Students will be able to design genetic crosses to provide information about genes, alleles and gene functions."

We also aligned the verb with the level of cognitive understanding expected of students. Table 1 shows levels of learning and examples of verbs that match each level [3, 4, 6-8]. Even in introductory courses, CU students are expected to learn, and benefit from learning, beyond the factual knowledge and comprehension level, so each course includes learning goals aligned with the higher levels of analysis, synthesis and evaluation.

At CU, we have also made an effort to craft learning goals that convey the relevance and usefulness of any particular content to students. Specifically, we used everyday language and applications where possible and were selective and minimal in the use of specific, technical terms. In addition, we did not limit learning goals to course-specific content. Many courses at CU include goals that focus on skills, habits of mind and affective outcomes such as: "Students should be able to justify their thinking and/or approach to a biological question, in either written or oral form."

Writing learning goals requires effort and time, but carries multiple benefits for the faculty who write the goals, their students and the department as a whole. Once defined, faculty turn to the learning goals as they plan class time, develop homework and write exams [9]. As a result, all aspects of the course become better aligned and focus on what faculty most want students to achieve. Faculty using learning goals also report that writing high-quality exam questions becomes faster and easier [10]. At CU, we have seen that the cognitive level of exams often increases as faculty align the questions with the higher cognitive level of the learning goals [11].

When faculty share learning goals with students, students and faculty both find substantial benefit from the improved communication [10]. At CU, faculty use a variety of ways to communicate learning goals, including posting them online and beginning each lecture by presenting the relevant learning goals for the day. One MCDB faculty member, Dr Bill Wood, explains that learning goals decrease frustrations for both students and faculty by giving the students an answer, up front, to the perennial question "what's going be on the final exam?" He adds:

> *Learning goals are student-centered, telling students what levels of understanding they should achieve and what they should be able to do when the course is completed.*

End-of-year surveys reveal that students are overwhelmingly positive about having access to learning goals [10]. Students report the greatest benefit is that learning goals let them "know what I need to know", which helps students focus on important ideas and study more effectively.

For departments, writing learning goals has informed, shaped and aligned the departmental curriculum. By considering the learning goals from multiple courses, departments have discovered that some concepts were taught in an identical manner in multiple courses and other critical concepts were omitted entirely. As a result, faculty members who teach different courses have begun to work together so that their goals complement each other and encompass what every student should be able to do by graduation. For instance, some fundamental evolution concepts were added to the MCDB curriculum after this process highlighted their absence.

Finally, one of the greatest benefits we have seen with learning goals is that their creation has increased intellectual discussion among faculty regarding education issues. These discussions not only include determining key learning goals, but also what types of promising educational practices can be used to teach and assess these goals. As more faculty are systematically measuring what their students are learning, they also continue to revise their learning goals to improve upon what students should be able to do at the end of each course.

Figure 1. Examples of learning goals from an introductory genetics course.

Course learning goal: Deduce information about genes, alleles and gene functions from analysis of genetic crosses and patterns of inheritance.

Topic learning goals:

a) Draw a pedigree based on information in a story problem.

b) Distinguish between different modes of inheritance.

c) Calculate the probability that an individual in a pedigree has a particular genotype or phenotype.

d) Design genetic crosses to provide information about genes, alleles and gene functions.

e) Use statistical analysis to determine how well data from a genetic cross or human pedigree analysis fits theoretical predictions.

Figure 2. Checklist for creating learning goals.

- ✔ Does the learning goal identify what students will be able to do after the topic is covered?
- ✔ Is it clear how you would test achievement of the learning goal?
- ✔ Do chosen verbs have a clear meaning?
- ✔ Is the verb aligned with the level of cognitive understanding expected of students? Could you expect a higher level of understanding?
- ✔ Is the terminology familiar or common? If not, is knowing the terminology a goal?
- ✔ Is it possible to write the goal so it is relevant and useful to students (for example, connected to their everyday life, or does it represent a useful application of the ideas)?

Table 1. Levels of cognitive understanding and corresponding verbs.

Level* of cognitive understanding	Description	Representative verbs
Factual knowledge	Remember and recall factual information	Define, list, state, label, name
Comprehension	Demonstrate understanding of ideas and concepts	Describe, explain, summarise, interpret, illustrate
Application	Apply comprehension to unfamiliar situations	Apply, demonstrate, use, compute, solve, predict, construct, modify
Analysis	Break down concepts into parts	Compare, contrast, categorise, distinguish, identify, infer
Synthesis	Transform and combine ideas to create something new	Develop, create, propose, formulate, design, invent
Evaluation	Think critically about and defend a position	Judge, appraise, recommend, justify, defend, criticise, evaluate

***The levels listed here are based on Bloom's taxonomy of the cognitive domain [7]. These levels are useful for distinguishing between higher and lower levels of thinking, but do not necessarily function as a strict hierarchy [8].**

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