



# The Mastery Rubric for Bioinformatics: supporting design and evaluation of education and training across the life sciences

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## Background: Mastery Rubric for Bioinformatics<sup>1</sup>

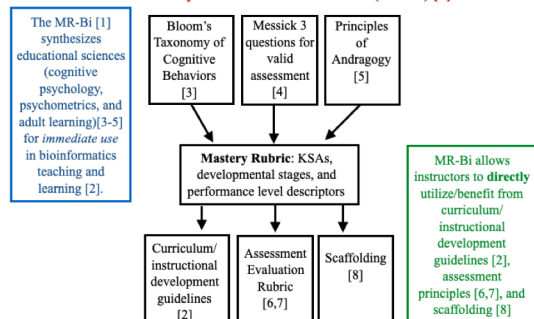
A Mastery Rubric (MR) is like a standard rubric: target Knowledge, Skills and Abilities (KSAs) are outlined, together with Performance Level Descriptors (PLDs) – describing how each KSA can evaluably be identified, ranging from less- (novice) to more- expert/independent (journeyman) execution. By contrast with standard rubrics, the MR describes the *entire curriculum* (rather than individual assignments). Instructors *and learners* can recognize and/or document progression according to the performance expected at different stages outlined in the MR. The Mastery Rubric for Bioinformatics (MR-Bi) covers **12 KSAs**: Prerequisite knowledge, biology; Prerequisite knowledge, computational methods; Interdisciplinary integration; Define a problem based on a critical review of existing knowledge; Hypothesis generation; Experimental design; Identify data that are relevant to the problem; Identify and use appropriate analytical methods; Interpretation of results; Draw and contextualize conclusions; Communication; Ethical practice. The MR-Bi has **5 stages**: Novice; Beginner; Apprentice; Early Journeyman; Late Journeyman.

## Background: curriculum and instructional development<sup>2</sup>

There are 5 phases of curriculum (and course) development for higher education<sup>2</sup>:

1. Select aims and Learning Outcomes (LOs);
2. Select Learning Experiences (LEs) that will help students achieve the aims and outcomes;
3. Select content that is relevant to outcomes (now and in future);
4. Prepare assessments to ensure learner progression towards outcomes; and
5. Evaluate the effectiveness of the LEs for leading learners to the outcomes.

### Mastery Rubric for Bioinformatics (MR-Bi) [1]



## Five Phases of Development:

### Learning Outcomes (LO)

- 1) PLDs provide ordered, concrete verbs for LO writing; supports planning/development and evaluation.
- 2) Differences in verbs across stages provide criteria for admission and qualification/completion.
- 3) LOs can be stated in terms of PLDs and stages; supporting articulation of concrete and observable outcomes.
- 4) Enables identification of redundancy in the curriculum to promote building up sophistication rather than repetition.
- 5) PLDs can align faculty (e.g., for courses taken in sequence).

### Learning Experiences (LE)

- 1) Much of traditional/existing LEs can be retained, if additional (extra curricular) opportunities are created to fill in any gaps.
- 2) KSAs and PLDs provide structure for flipping classrooms and trying other innovative teaching techniques/LEs.
- 3) KSAs, PLDs, and stages help guide curriculum revisions/trying new methods.

### Content

- 1) MR-Bi KSAs are all derived based on the scientific method, and a variety of content (bioinformatics techniques and reasoning for technological and/or scientific innovation) can be used to teach, provide practice, and assess what learners learn and can do.
- 2) MR-Bi provides rationale for instruction in/with new technology/methods (content) without deviating from LOs around scientific method KSAs and MR movement towards independence.
- 3) Enables instructors and curriculum developers to engage with/integrate multiple – diverse – content guidelines.

### Assessment (of learners)

- 1) PLDs support targeting of instruction and alignment of LOs with assessment.
- 2) Capitalize on observability of PLD verbs to design assessments that will be aligned with curricular LOs.
- 3) Sharing the MR-Bi with all learners, and encouraging them to understand the alignment of all courses in the curriculum with the curricular LOs allows them to self-direct (as learners) and utilize assessments to gauge their progress along the MR-Bi KSA trajectories.
- 4) The PLDs allow faculty to focus assessments and to add opportunities for peer evaluation that further LOs as well as increasing opportunities for formative feedback.

### Evaluation (of impact of curriculum on learners)

- 1) Curriculum can be evaluated for whether LOs were/were not achieved for most learners, focusing on KSAs, and possibly developmental stages, where failures of the curriculum to promote LOs occurred (or occurred most often). LOs can also be evaluated for how realistic they were.
- 2) Sharing the MR-Bi (as intended) can support metacognition throughout the curriculum, to promote self-directed learning beyond the end of the curriculum. Curriculum evaluation can focus on this.

## MR-Bi supports developing the curriculum

- 1) Provides ordered, concrete verbs for LO writing to facilitate focus in a given course
- 2) Supports realistic outcomes given time and prerequisites (LOs can be stated in terms of PLDs and stages)
- 3) Supports self-directed learners' identification of individualized LOs –leading them to, or following from, the course.
- 4) PLDs can be used to articulate trajectory for courses to be taken in sequence.

- 1) Focuses instruction and LEs so that realistic LOs can be accomplished with a variety of content.
- 2) Enables exploration/creativity in LEs as long as they support the specific (target) KSA(s) and levels that learners want/need.

- 1) Allows demonstration of relevance of any given content to the learners' goals/career stage.
- 2) Supports the use of diverse content to enable deeper learning (for greater retention).
- 3) Supports learners' engaging in their own growth (by enabling their selection of specific learning/content).
- 4) PLDs allow multiple instructional opportunities at targeted, consistently-graded levels (beginner, median, advanced).
- 5) Facilitates the 'cloning' of workshops or courses where KSAs are specifically targeted (or documented) while content can vary.

- 1) MR-Bi PLDs clarify what learners need to demonstrate, so that "satisfaction" or other survey-based assessments can be replaced with assessments that are aligned with LOs.
- 2) Sharing the MR-Bi with learners, and encouraging them to understand the alignment of the course with the LOs allows them to demonstrate how they a) self direct (as learners) and b) can utilize assessments to gauge their progress along the MR-Bi KSA trajectories.

- 1) Promotes targeted follow-up (e.g., "if you met the course LOs, did you move on/continue to refine at a level since then?")
- 2) Strengths and weaknesses in courses can be identified and addressed according to whether LOs, stated in terms of PLDs and stages, were a) reasonable for the time and preparedness of learners; and b) sufficiently supported by the LEs.

## References

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