*Assess this: Educational Assessment Challenges and Practical Solutions Symposium 2015*

# Using concept inventory questions to measure student understanding and assess teaching methodologies

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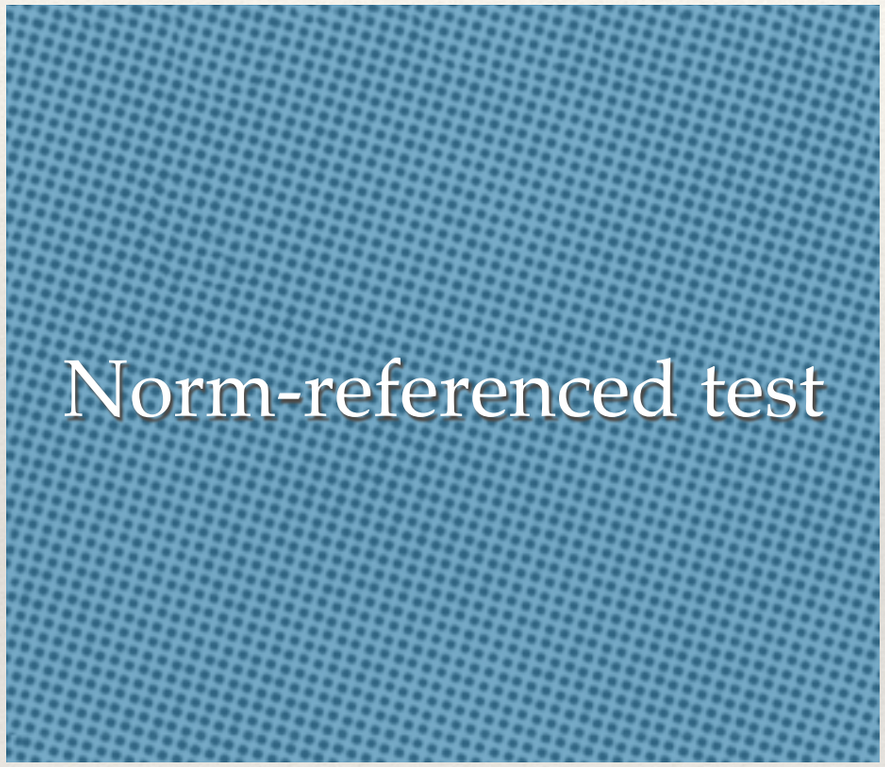
# Outline

- What is a concept inventory?
- Differences from Student assessment
- How are used and created?
- Implementation in Biology 108 Blended Learning Project

# What is a concept inventory?

- "Series of questions designed to determine whether a student has an accurate working knowledge of a specific set of concepts for a given field." Wikipedia
- "A Concept Inventory is an outline of core knowledge and concepts for a given field and a collection of multiple choice questions designed to probe student understanding of these fundamental concepts." Radish 2000

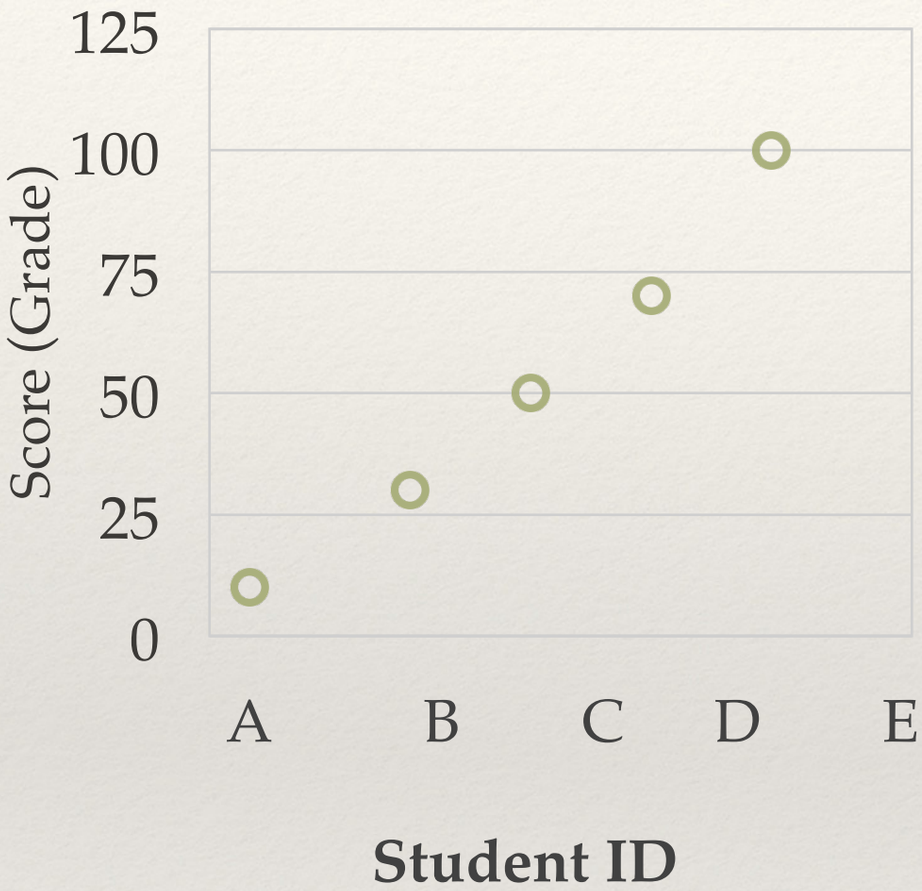
# Differences from student assessment

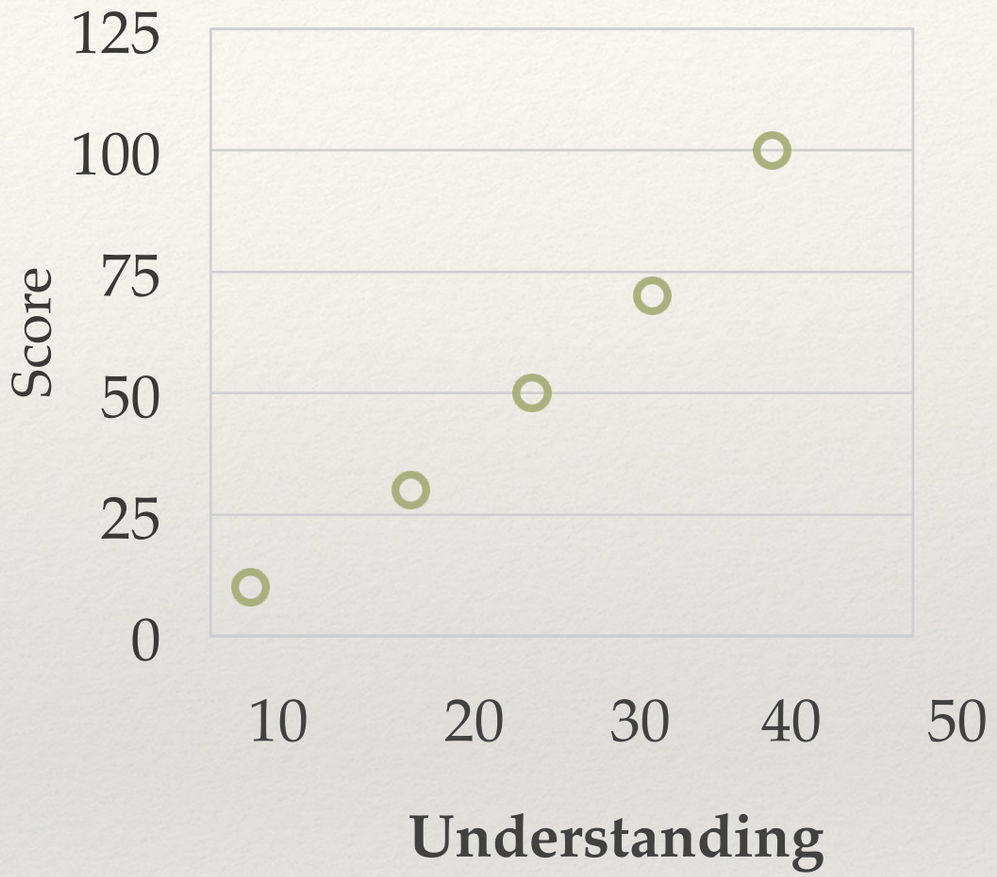



Student assessment


Concept Inventory

# Differences from student assessment




Norm-referenced test

Student assessment

Criterion-referenced test

Concept Inventory

# Differences from student assessment

| Concept Inventory | Student Assessment |
| --- | --- |
| Student's conceptual understanding | Tests knowledge but not necessarily understanding |
| Distractors use common student misconceptions. | Distractors not necessarily based on misconceptions. |
| Based on peer review. Research component. | Not based on research. |

# Uses of concept inventories

- 1. Assessing student understanding
- 2. Assessing learning gains
- 3. Assessing misconceptions
- 4. Assessing teaching methodologies

# Constructing concept inventories

- 1. Determine key concepts that are essential for area of study
- 2. Determine common misconceptions
- 3. Develop multiple choice questions
- 4. Create test
- 5. Validate

# Constructing concept inventories

- 1. Determine key concepts that are essential of area of study
  - Based on survey of literature. E.g. Concept inventory of Natural Selection (Anderson 2002) or Force Concept Inventory (Hestenes 1992)
  - Based on learning outcomes/objectives for course

# Constructing concept inventories

- 2. Determine common misconceptions
  - Past exams.
  - Published concept inventories.
  - Student interviews.
  - Opened ended questions.

# Constructing concept inventories

- 3. Develop multiple choice questions
  - Questions can come from published concept inventories
  - Or where questions do not exist create new ones
  - Include correct answer as well as common misconceptions

# Constructing concept inventories

- 4. Create test
- Factual knowledge
- Mechanisms and beliefs

# Constructing concept inventories

- 5. Validate:
  - Discriminability
  - Consistency amongst test groups
  - Internal consistency of test

# Assessing efficacy of Biology 108 Blended Learning

- Blended Learning Award 2015 - PDLC
- Converting six topic areas
- Assess the efficacy of the conversions
  - Does blended learning improve learning gains in Biology 108?

# Assessing efficacy of Biology 108 Blended Learning

- Cross over Experimental Design
  - Blended learning vs Traditional learning
  - between sections
  - within section

| | Sec1 | Sec2 |
|---|---|---|
| Module 1 | BL | TL |
| Module 2 | TL | BL |
| Module 3 | BL | BL |
| Module 4 | BL | TL |
| Module 5 | TL | BL |
| Module 6 | BL | BL |

# Assessing efficacy of Biology 108 Blended Learning

- CI questions at the start of each module.
  - Online or in-class clicker questions
- Short CI test after each module
  - Learning gains
- Surveys at the end of some of the modules
  - Engagement and satisfaction
- Interviews with a subset of students

# Assessing efficacy of Biology 108 Blended Learning

- Relationships amongst:
- 1. Learning gains (understanding)
- 2. Satisfaction
- 3. Engagement
- 4. Grades

# Developing Concept Inventories

| | Inventory | Team | Development Phase | Courses | # of Students Involved |
|---|---|---|---|---|---|
| Completed | 0. General Student Misconceptions in Biology | Joan Sharp | Reviewed student misconceptions and questions designed to address them (preliminary work). | | |
| | 1. Meiosis | Pam Kalas<br>Carol Pollock<br>Jennifer Klenz<br>Angie O'Neill | 18 questions were validated through student interviews and were classroom tested. | BIOL 121<br>BIOL 334 | ~800 |
| | 2. Operon | Jared Taylor<br>Elizabeth Imrie<br>Karen Smith<br>George Spiegelman | 25 questions were validated through student interviews and were classroom tested. | BIOL 112 | ~1700 |
| | 3. Population and Community Ecology | Malin Hansen<br>Thomas Deane<br>Greg Bole<br>Brett Couch | 19 questions were validated through student interviews and were classroom tested. | BIOL 121<br>BIOL 230<br>BIOL 304 | ~800 |
| | 4. Speciation | Erica Jeffery<br>Michelle Tseng<br>Greg Bole | 16 questions were validated through student interviews and were classroom tested. | BIOL 121 | ~600 |
| In Progress | 5. Transcription and Translation | Rosemary Oh-McGinnis<br>Jared Taylor<br>Sunita Chowrira | 27 questions are currently being developed. Classroom testing will be done in BIOL 112 and BIOL 200. | BIOL 112<br>BIOL 200 | ~10 |
| | 6. Experimental Design | Thomas Deane<br>Kathy Nomme<br>Carol Pollock | 25 questions are currently being developed. Classroom testing will be done in BIOL 140. | BIOL 140 | ~25 |
| | 7. Microevolution | Michelle Tseng<br>Greg Bole | 15 questions are currently being developed. Classroom testing will be done in BIOL 121 and BIOL 336. | BIOL 121<br>BIOL 336 | ~25 |

Birol et al, 2012

UBC Biology

- Multiple concept inventories in biology developed or developing.

# Developing Concept Inventories

**1) NATURAL SELECTION**

*Conceptual Inventory of Natural Selection (CINS) (20 MC items, scenarios)*

Anderson DL, Fisher, KM, Norman JG. 2002. Development and validation of the conceptual inventory of natural selection. *Journal of Research in Science Teaching* **39**: 952-978.

Anderson DL. 2003. Natural selection theory in non-majors' Biology: instruction, assessment, and conceptual difficulty. Thesis (Ph.D.) University of California, San Diego and San Diego State University, San Diego, CA.

**2) MACROEVOLUTION**

*Measure of Understanding of Macroevolution (MUM) (28 items: 27 MC items, plus one open- ended item, diagrams)*

Nadelson LS, Southerland SA. 2010. Development and preliminary evaluation of the Measure of Understanding of Macroevolution: Introducing the MUM*. The Journal of Experimental Education* **78**: 151–190.

**3) EVOLUTIONARY RELATIONSHIPS**

*Basic Tree Thinking Assessment (two tests, 10 MC items each, diagrams) Baum DA, Smith SD, Donovan SSS. 2005. The tree-thinking challenge. Science **310**: 979-980.*

**4) GENETICS LITERACY**

*Genetics Literacy Assessment Instrument (GLAI) (31 MC items)*
*FOUR ITEMS PROVIDED in Bowling et al. Genetics 2008; ALL in Moskalik 2007)*

Bowling BV, Acra EE, Wang L, Myers MF, Dean GE, Markle GC, Moskalik CL, Huether CA. 2008. Development and evaluation of a genetics literacy assessment instrument for undergraduates. *Genetics* **178**: 15-22.

Bowling BV, Huether CA, Wang L, Myers MF, Markle GC, Dean GE, Acra EE, Wray FP, Jacob, GA. 2008. Genetic literacy of undergraduate non-science majors and the impact of introductory biology and genetics courses. *BioScience* **58:** 654-660.

# Developing Concept Inventories

**5) GENETICS**

*Genetics Concept Assessment (GCA) (25 MC items, diagrams) ISmith MK, Wood WB, Knight JK. 2008. The genetics concept assessment: A new concept inventory for gauging student understanding of genetics. CBE Life Sci Edu **7**, 422-430.*

*additional future tests to be posted online at www.colorado.edu/sei/departments/mcdb_assessment.htm*

**6) GENETICS**

*Genetics Literacy (13 two-tiered MC items, diagrams)Tsui CY, Treagust D. 2009. Evaluating secondary students' scientific reasoning in genetics using a two-tier diagnostic instrument. International Journal of Science Education **32**: 1073-1098.*

**7) INTRODUCTORY BIOLOGY**

*Biology Concept Inventory (BCI) (30 MC items)*
*ITEMS PROVIDED ON-LINE at http://bioliteracy.colorado.edu/*

Klymkowsky MW, Garvin-Doxas K, Zeilik M. 2003. Bioliteracy and teaching efficacy: What biologists can learn from physicists. *Cell Biol Educ* **2**: 155-161.

Garvin-Doxas K, Klymkowsky MW, Elrod S, 2007. Building, using, and maximizing the impact of concept inventories in the biology education: a meeting report. *CBE- Life Science Education* **6:** 277-282.

Klymkowsky M.W., K. Garvin-Doxas. 2008. Recognizing students' misconceptions through Ed's tools and the Biology Concept Inventory. PloS Biology 6: e3. doi:10.1371/journal.pbio.0060003.

Garvin-Doxas K, Klymkowsky MW. 2008. Understanding randomness and its impact on student learning: Lessons learned from building the Biology Concept Inventory (BCI). *CBE-Life Sciences Education* **7:** 227–233.

**8) ANIMAL DEVELOPMENT**

*Developmental Biology Content Survey (15 MC items) Knight JK, Wood WB. 2005. Teaching more by lecturing less. Cell Biology Education **4**: 298-310.*

# Types of assessment

- Satisfaction - USRI
- Engagement - NSSE
- Student assessment - Tests and exams
- Understanding - Concept inventories

# Summary

- What is a concept inventory?
- Differences from Student assessment
- How are used and created?
- Implementation in Biology 108 Blended Learning Project

# Thanks to

- Norma Nocente - Center for Teaching and Learning
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