Parimal and Pramod Chaudhari
Centre for Learning and Teaching

Indian Institute of
Technology Bombay

Developing Course Assessment Plans to Support Learning

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Workshop Overview

- **Part 1:** Writing Effective Course Learning Outcomes
  - Morning, Wednesday, 8 January 2020
- **Part 2:** Applying Research-based Instructional Strategies
  - Afternoon, Wednesday, 8 January 2020
- **Part 3:** Developing Course Assessment Plans
  - Morning, Thursday, 9 January 2020
- **Part 4:** Facilitating Student Use of Metacognitive Learning Strategies
  - Afternoon, Thursday, 9 January 2020

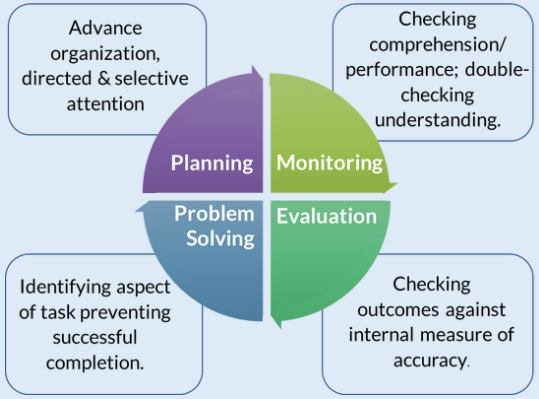
Workshop Overview

Writing Effective Learning Outcomes

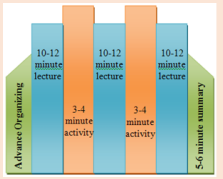
Designing Course Assessment Plans Aligned with Learning Outcomes

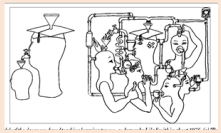
	Where the learner is going	Where the learner is	How to get there
Teacher	Clarifying, sharing and understanding learning intentions	Engineering effective discussions, tasks, and activities that elicit evidence of learning	Providing feedback that moves learners forward
Peer		Activating students as learning resources for one another	
Learner		Activating students as owners of their own learning	

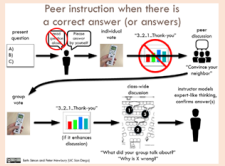
Facilitating Student Use of Metacognitive Learning Strategies

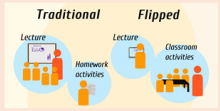


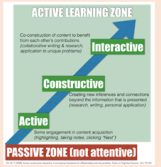
Designing Research-based Instructional Strategies Aligned with Learning Outcomes

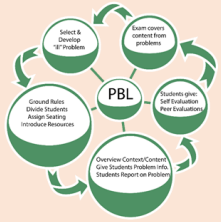


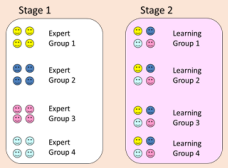












Workshop Ground Rules

- **Ownership:** It is your workshop
- **Questions:** Ask when you have a question.
- **Slides:** The most recent copy of the slides will be available after the workshop
- Purposes of the Slides
  - Guide Workshop
  - Second Visual Source of Information
  - Resource after Workshop

	Where the learner is going	Where the learner is	How to get there
Teacher	Clarifying, sharing and understanding learning intentions	Engineering effective discussions, tasks, and activities that elicit evidence of learning	Providing feedback that moves learners forward
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Part 1

Assessment and Learning: Overview

Purpose of Assessment

- The primary purpose of assessment is to enable decision makers (i.e., faculty and students) to make better decisions!
- To make better decisions, decision makers must be **clear** about what the decisions are intended to achieve.

Purposes of Assessment

	Where the learner is going	Where the learner is	How to get there
Teacher	Clarifying, sharing and understanding learning intentions	Engineering effective discussions, tasks, and activities that elicit evidence of learning	Providing feedback that moves learners forward
Peer		Activating students as learning resources for one another	
Learner		Activating students as owners of their own learning	

Siobhan, L., Lyon, C., Thompson, M., & Wiliam, D. (2005). Classroom assessment: Minute by minute, day by day. *Educational Leadership, 63*(3), 18-24.

Assessment of Student Learning Outcomes

	Assessment Method No. 1	Assessment Method No. 2	...	Assessment Method No. M
Learning Outcome No. 1				
Learning Outcome No. 2				
...				
Learning Outcome No. N				

Assessment of Student Learning Outcomes
Why do you care?

- Assessment, not lecture, drives learning
- Since the primary purpose of assessment is to help faculty and students make better decisions, the first step is greater clarity about the intent of the decisions
- When you and your students are clearer about the intent of learning, motivation is greater.

Feedback through Systematic Formative Assessment

- “A recent review (Black and William, 1998) revealed that classroom-based formative assessment, when appropriately used, can positively affect learning.....students learn more when they receive feedback about particular qualities of their work, along with advice on what they can do to improve” (National Research Council, 2001)

- National Research Council (2001). *Knowing What Students Know: The Science and Design of Educational Assessment.* Washington, DC: National Academies Press.
- Black, P., & Wiliam, D. (1998). Assessment and Classroom Learning. *Assessment in Education: Principles, Policy & Practice, 5*(1), 7–74.

Feedback through Systematic Formative Assessment

- In their synthesis of 12 meta-analyses (including 196 studies and 6,972 effect sizes) reviewing factors that influence student learning and achievement, Hattie and Timperley (2007) report an average effect size of 0.79 for the influence of feedback on learning and achievement.
- This was twice the average effect size of several factors that influence student learning and achievement, and it placed feedback among the top ten influences on student achievement.

Hattie, J., & Timperley, H. (2007). The power of feedback. Review of Educational Research, 77(1), 81-112. https://doi.org/10.3102/003465430298487

Effective Principles for Learning		Low-performing Practices for Learning
Retrieval	**Metacognition**	
Retrieval	Calibration	Highlighting
Spaced Retrieval	Reflection	Rereading
Interleaved Retrieval	Self-explanation	Summarization
Generative Practice	Planning, Monitoring, Evaluating, Revising	Imagery Use for Text Learning
Elaboration		Keyword Mnemonic

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*(1), 4-58. https://doi.org/10.1177/1529100612453266

People do not learn what they receive.

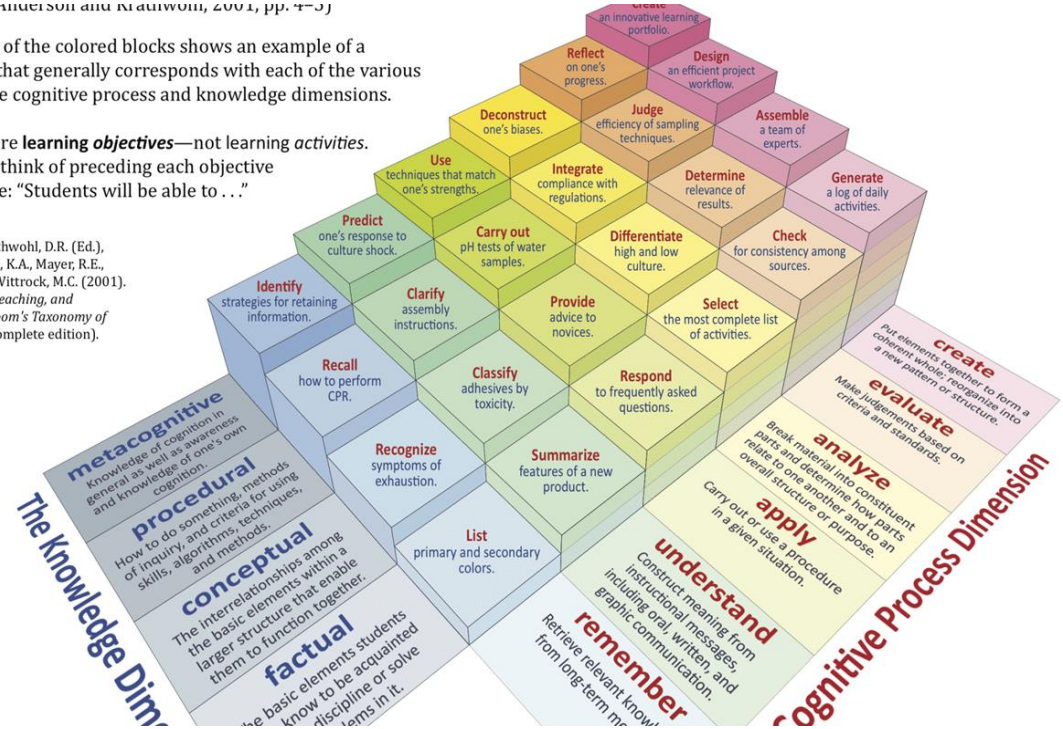
People learn what they **retrieve**.

of construct. (Anderson and Krathwohl, 2001, pp. 4–5)

In this model, each of the colored blocks shows an example of a learning objective that generally corresponds with each of the various combinations of the cognitive process and knowledge dimensions.

Remember: these are **learning *objectives***—not learning *activities*. It may be useful to think of preceding each objective with something like: "Students will be able to . . ."

*Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Complete edition). New York: Longman.



Part 2

Assessment Terminology

Assessment Terminology

- Formative Assessment
  - The purpose of formative assessment is to provide information to learners (students and teachers) to help them **improve** their learning.
- Summative Assessment
  - The purpose of summative assessment is to **evaluate** learning at the end of a prescribed period of time.

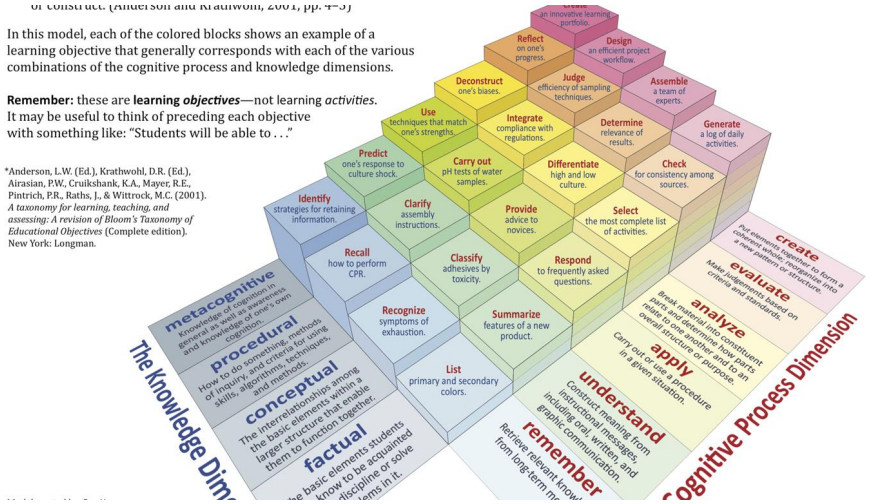
Assessment Terminology

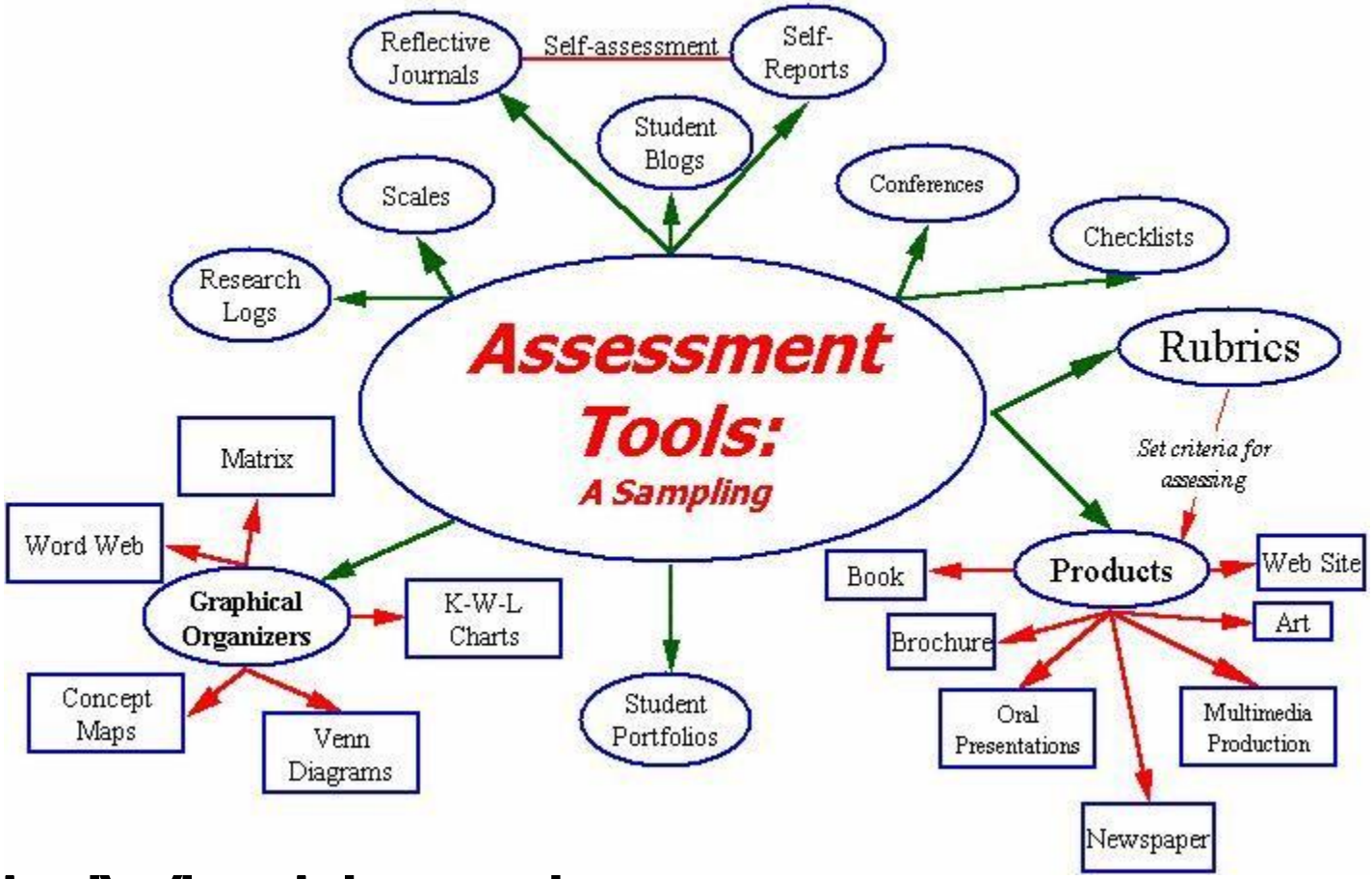
Formative Assessment	Summative Assessment
Low Stakes	High Stakes
Purpose: Improvement	Purpose: Evaluation
Help students identify their strengths, i.e., what does not need much additional studying	Help students understand where they stand at the conclusion of a unit, course, curriculum, etc.
Help students identify their areas for improvement, i.e., what needs additional studying	
Help faculty members pinpoint where students need additional support	Support faculty in their decisions about grading students at the conclusion of a unit, course, curriculum, etc.

What is the difference between formative and summative assessment? https://www.cmu.edu/teaching/assessment/basics/formative-summative.html

Assessment & Bloom's Revised Taxonomy

Principle: Choice of assessment methods for a learning outcome should be guided, in part, by the classification of the learning outcome using Bloom's Revised Taxonomy.





Part 3

Assessment Methods

Assessment Methods: Student Learning

Concept Maps

Concept Inventories

Assessing Prior Knowledge

Classroom Assessment Techniques

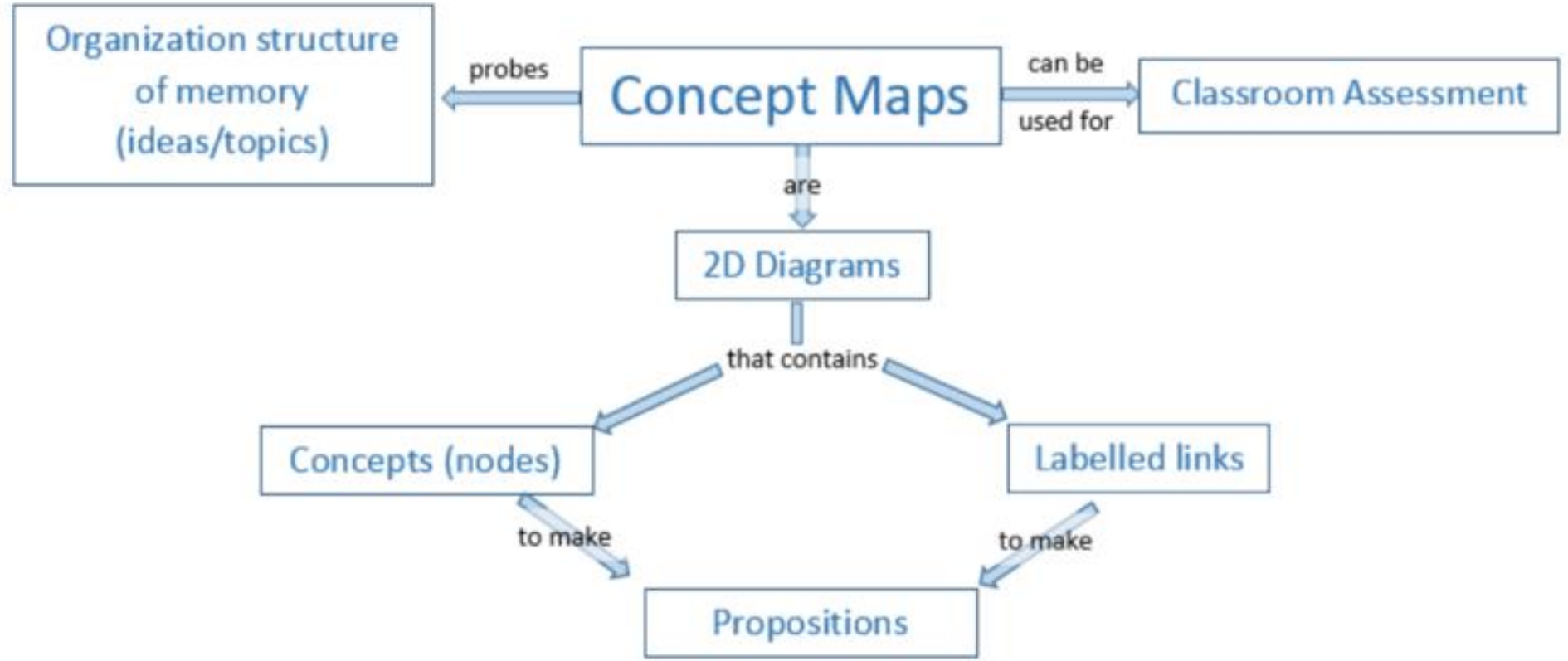
- Minute Papers

Student Response Systems (Clickers)

Performance Rubrics

Exams

Assessing Student Learning, Eberly Center, Carnegie Mellon University: https://www.cmu.edu/teaching/designteach/teach/assesslearningteaching.html



Part 3i

Concept Maps

Concept Maps

Nesbit, J. C., & Adesope, O. O. (2006). Learning with concept and knowledge maps: A meta-analysis. *Review of Educational Research, 76*(3), 413-448. https://dx.doi.org/10.3102/00346543076003413

Blunt, J. R., & Karpicke, J. D. (2014). Learning with retrieval-based concept mapping. J*ournal of Educational Psychology, 106*(3), 849-858. https://dx.doi.org/10.1037/a0035934

Recommendation: Use concept maps as a retrieval practice exercise.

Concept Maps

- One of the major differences between novices and experts is how they organize information.
- A concept map or conceptual diagram is a diagram that depicts suggested relationships between concepts.
  - Reference: https://en.wikipedia.org/wiki/Concept_map
- Asking students or teams of students to develop a concept map encourages them to organize and/or reorganize concepts and how they link concepts to applications
  - Reference: http://cmap.ihmc.us/docs/theory-of-concept-maps
- Cmap: https://cmap.ihmc.us/
- Concept maps are one form of graphic organizers.
  - Reference: https://www.edrawsoft.com/graphic-organizers-benefits.php

Concept Maps

One-Minute Exercise

- Think of a course you will be teaching.
- Generate at least 3 ideas for how you might use concept maps to support student learning in your course.

AIChE Education Division

CONCEPT WAREHOUSE

Part 3ii

Concept Questions and Concept Inventories

Concept Questions

Concept Questions (aka ConcepTests) are conceptual multiple-choice questions that are designed to:

- Focus on a single concept
- Focus on qualitative reasoning, i.e., they do not ask for numerical answers
- Encourage improved conceptual understanding, i.e., the wrong answers (aka distractors) are answers learners with naïve understanding often pick
- Have good multiple-choice answers

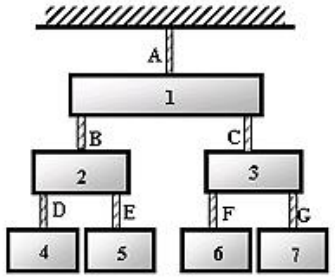
ConcepTests: https://serc.carleton.edu/introgeo/interactive/conctest.html

AIChE Concept Warehouse

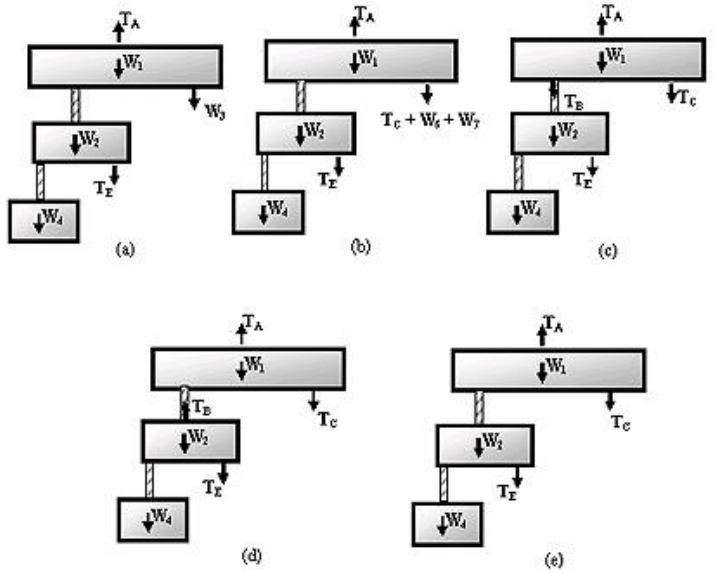
- https://jimi.cbee.oregonstate.edu/concept_warehouse/
- Number of Available Concept Questions: 2,937
- Number of Faculty Accounts: 1,142
- Number of Concept Questions Answered: 1,200,088
- Number of Students Learning: 27,550

Concept Questions

A free body diagram is to be constructed of the combination of blocks 1, 2 and 4 and the cords connecting them.



Which is the correct free body diagram?



One-Minute Exercise

- Think of a course you will be teaching.
- Generate at least 3 ideas for how you might use concept questions to support student learning in your course.

Concept Inventories

A concept inventory is a criterion-referenced test designed to help determine whether a student [can qualitatively reason with] a specific set of concepts.

Historically, concept inventories have been in the form of multiple-choice tests in order to aid interpretability and facilitate administration in large classes.

Wikipedia: https://en.wikipedia.org/wiki/Concept_inventory

Concept Inventories

Unlike a typical, teacher-authored multiple-choice test, questions and response choices on concept inventories are the subject of extensive research.

Concept inventories are evaluated to ensure test reliability and validity. In its final form, each question includes one correct answer and several distractors.

Wikipedia: https://en.wikipedia.org/wiki/Concept_inventory

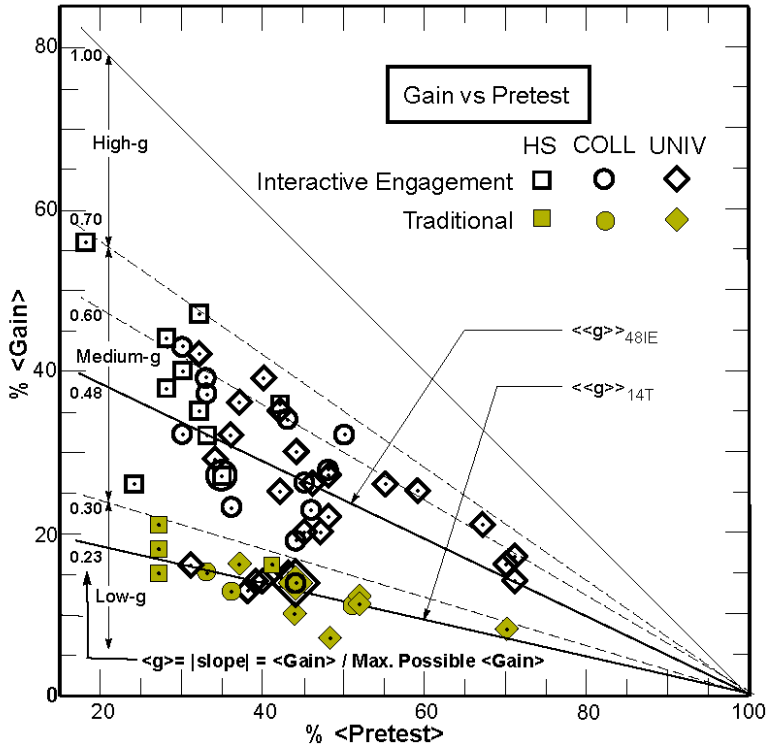
Force Concept Inventory

- Developed by by Hestenes, Halloun, Wells, and Swackhamer
- The FCI was designed to assess student understanding of the Newtonian concepts of force and motion.
- Hestenes found that while "nearly 80% of the [students completing introductory college physics courses] could state Newton's Third Law at the beginning of the course. FCI data showed that less than 15% of them fully understood it at the end".

Halloun, I. A., & Hestenes, D. Common sense concepts about motion (1985). *American Journal of Physics, 53*, 1043-1055.
Reference: Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher, 30*(3), 141-158. https://dx.doi.org/10.1119/1.2343497

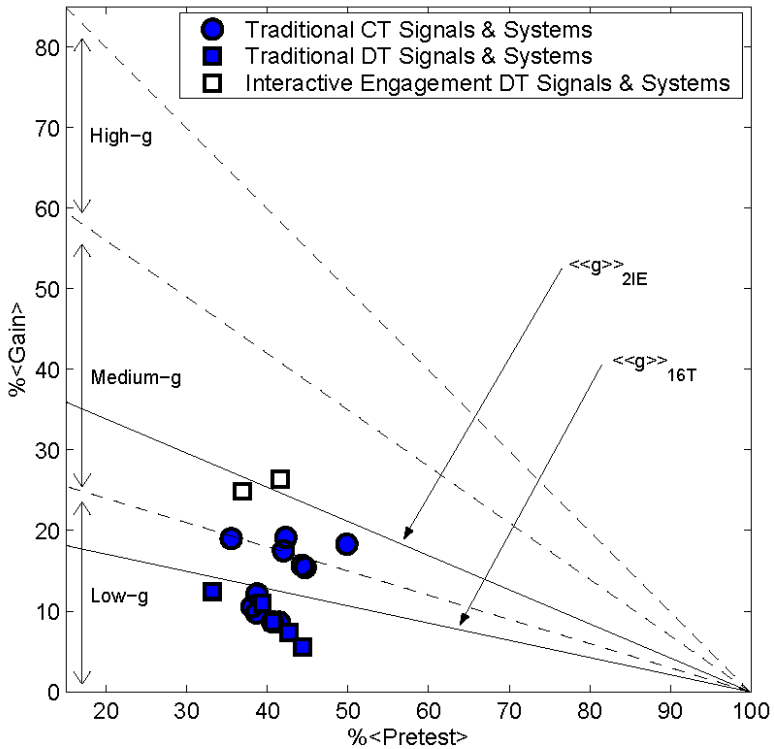
Comparison of Hake's FCI gain results to SSCI gain results

FCI



FCI gain results (Hake 1998)
Traditional avg gain = 0.23± 0.04
Interactive avg gain = 0.48±0.14

SSCI



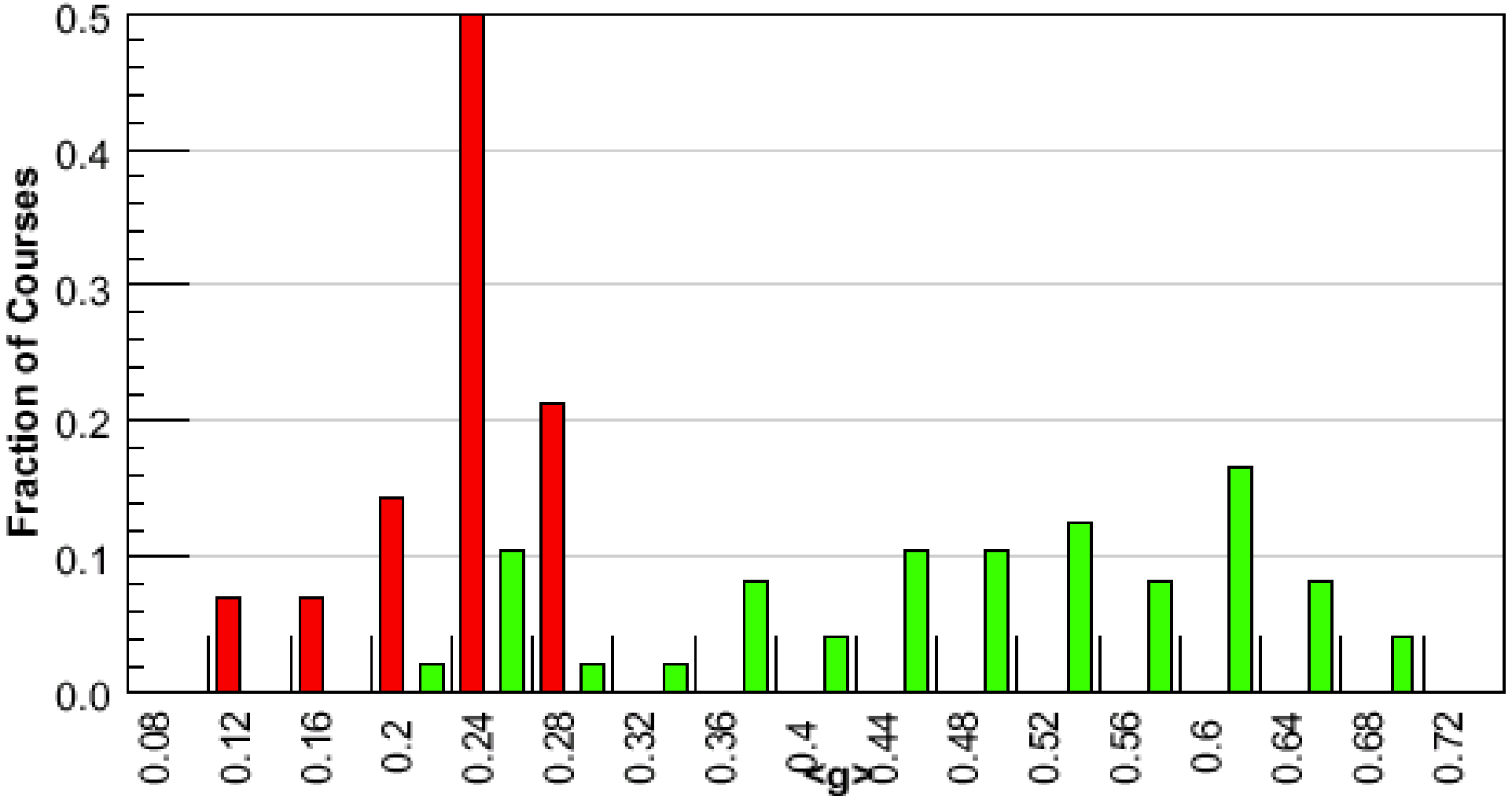
SSCI v2.0 gain results (Wage/Buck)
Traditional avg gain = 0.21± 0.08
Interactive avg gain = 0.42± 0.04

Normalized Gain – Richard Hake

$$\langle g \rangle = \frac{\langle post \rangle - \langle pre \rangle}{100 - \langle pre \rangle}$$

Normalized Gain: https://www.physport.org/recommendations/Entry.cfm?ID=93334

Why Research-based Instructional Strategies

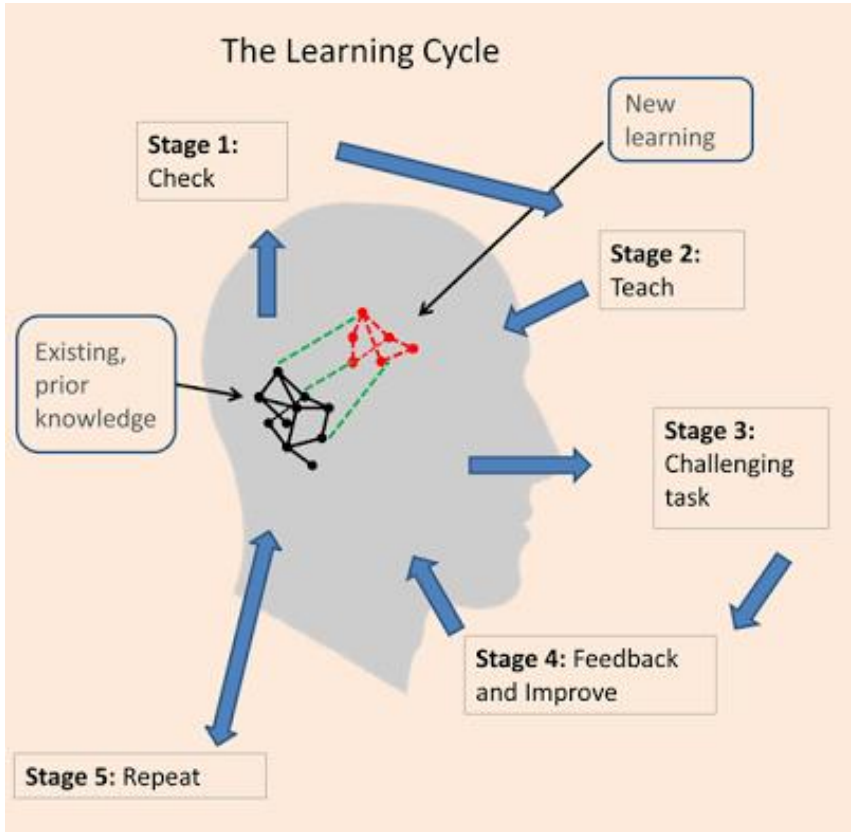


Hake, R. R., (1998). Interactive-engagement vs. traditional methods: A six-thousand student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66, 64- 74

Concept Inventories

Concept inventories have been created for physics, engineering, biology, chemistry, computer science, etc.

Recommendation: If there is a validated concept inventory is available for a course you are teaching, I recommend you consider using it when teaching your course.



Part 3iii

Assessing Prior Knowledge

Assessing Prior Knowledge

A student's prior knowledge of content relevant to the course they are beginning to take is the most influential predictor of their performance in the course.

Recommendation: Develop a set of learning incomes (i.e., learning outcomes describing expectations for student knowledge at the start of the course)

Methods for Assessing Prior Knowledge

- Concept Inventories
- Concept Maps
- Background Knowledge Probes

Assessing Prior Knowledge, Eberly Center, Carnegie Mellon University: https://www.cmu.edu/teaching/designteach/teach/priorknowledge.html

Background Knowledge Probe

“A Background Knowledge Probe (BKP) is a focused questionnaire that students fill out at the start of a unit (or course) to help teachers identify the best starting point for the class as a whole.”

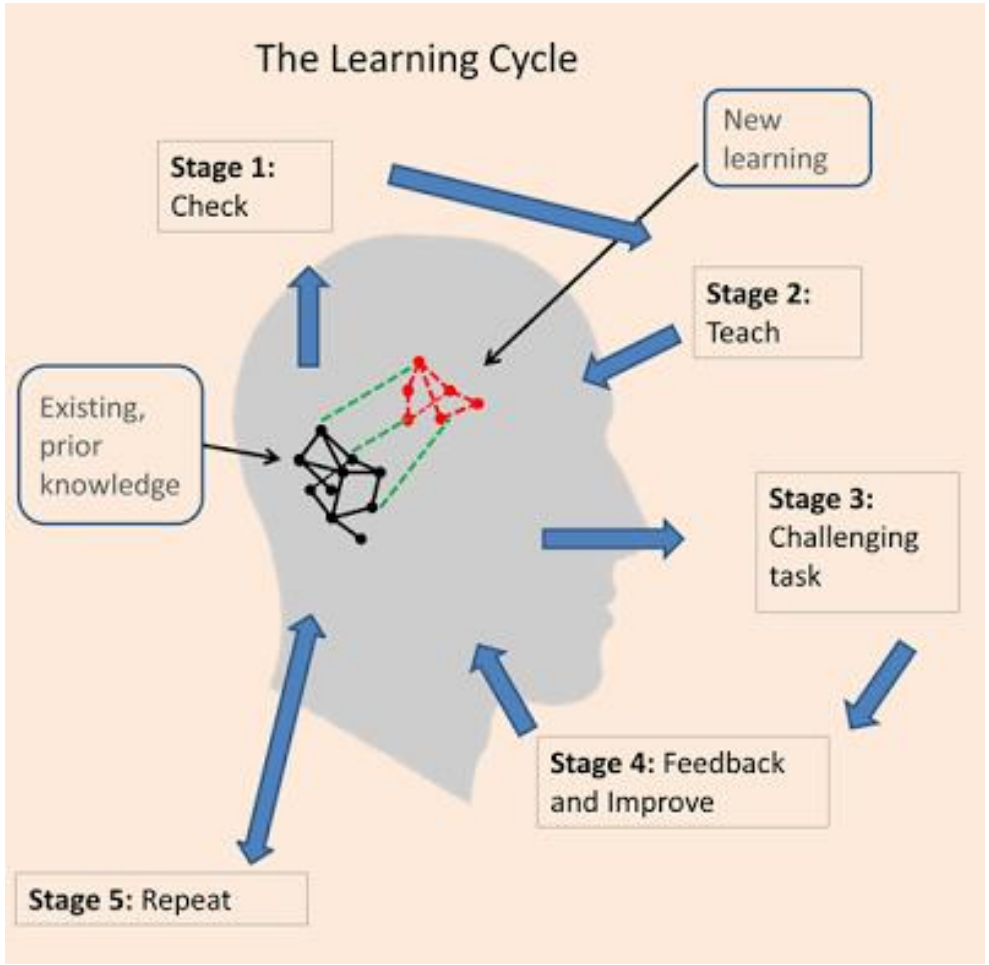
Student Self-assessment

Recommendation: Align your background knowledge probe with your learning incomes.

K. Patricia Cross Teaching Academy: https://kpcrossacademy.org/

The K. Patricia Cross Academy, Instructor's Guide, Teaching Technique 31: Background Knowledge Probe: https://kpcrossacademy.org/wp-content/uploads/2018/09/Cross-Academy-Download-Sheet-Technique31-Background-Knowledge-Probe.pdf

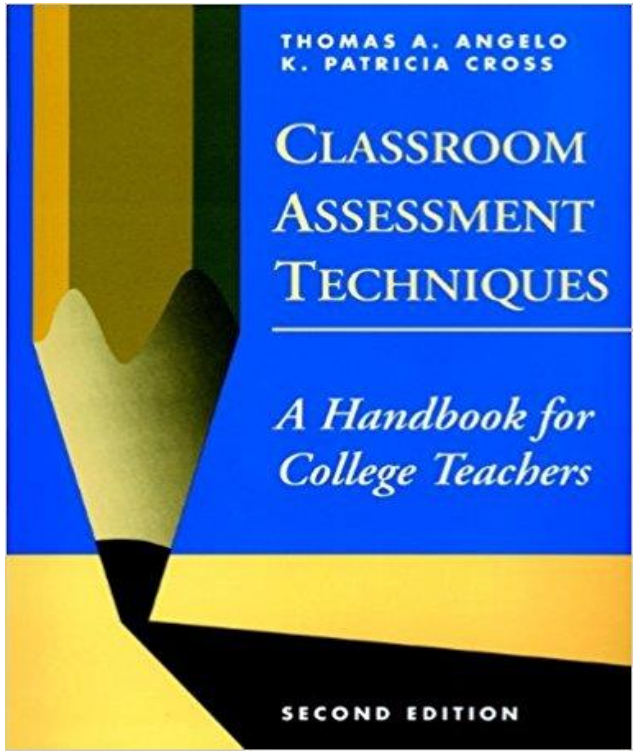
Assessing Prior Knowledge



1: Prior Knowledge: https://ebtn.org.uk/prior-knowledge/

One-Minute Exercise

- Think of a course you will be teaching.
- Generate at least 3 ideas for how you assess prior knowledge and use the results to support student learning in your course.



Part 3iv

Minute Papers and Classroom Assessment Techniquest

Minute Paper

At the end of each class period, write brief answers to the following questions:

- What is most valuable or helpful idea or concept that you learned today?
- What is the “muddiest or most confusing point” about in today’s lecture?

Variations on a Minute Paper

At the end of each class period, write brief answers to the following questions:

- Write a one-sentence summary of the content of the class period today.
- What is one potential application of today's content to your career aspirations?
- What is the muddiest point in today's class period?

How well does using minute papers in courses work?

- **Findings:** “This result suggested, as we hypothesized, that the use of the one-minute paper improves student performance. Its coefficient implied that the use of the one-minute paper increased student performance by approximately .5 of a point on the postTUCE exam, ceteris paribus.”
- **Findings:** “This evidence suggests that the benefit to students from using the one-minute paper does not depend on the instructor who implements it.”
- **Findings:** “This evidence supported our initial hypothesis that the benefit to students from using the one-minute paper does not depend on their ability level.”
- **Assertion:** “When asked by college teachers to identify the single pedagogical innovation that would most improve their teaching, Light (1990, 35) always responds with the one-minute paper, an idea that ‘swamped all others.’”

Chizmar, J. F., and Ostrosky, A. L. (1998). The One-Minute Paper: Some Empirical Findings. *The Journal of Economic Education, 29*(1), 3–10. https://doi.org/10.1080/00220489809596436

How well does using minute papers in courses work?

- **Findings:** Overall results indicate that performance on subsequent essay quizzes was significantly higher by students who wrote one-minute papers than performance by students who did not write the papers.
- **Findings:** Of particular interest to instructors was that the increase in quiz scores when one-minute papers were not graded was significantly higher than when the one-minute papers were graded.

Almer, E. D., Jones, K., and Moeckel, C. L. (1998). The impact of one-minute papers on learning in an introductory accounting course. *Issues in Accounting Education, 13*(3), 485–495

Minute Papers: References

Chizmar, J. F., and Ostrosky, A. L. (1998). The One-Minute Paper: Some Empirical Findings. *The Journal of Economic Education, 29*(1), 3–10. https://doi.org/10.1080/00220489809596436

Almer, E. D., Jones, K., and Moeckel, C. L. (1998). The impact of one-minute papers on learning in an introductory accounting course. Issues in Accounting Education, 13(3), 485–495

Stead, D. R. (2005). A review of the one-minute paper. *Active Learning in Higher Education, 6*(2), 118-131. https://dx.doi.org/10.1177/1469787405054237

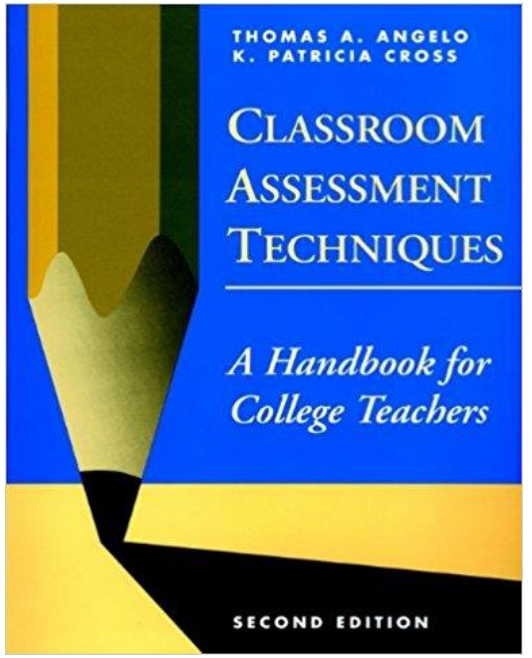
Minute Paper

One-Minute Exercise

- Think of a course you will be teaching.
- Generate at least 3 ideas for how you might use minute papers to support student learning in your course.

Classroom Assessment Techniques

"Classroom Assessment Techniques (CATs) are generally simple, non-graded, anonymous, in-class activities designed to give you and your students useful feedback on the teaching-learning process as it is happening."



Examples:

- **Background Knowledge Probe**
- **Minute Paper**
- **Muddiest Point**
- **What's the Principle?** This CAT provides students with a few problems and asks them to state the principle that best applies to each problem.

Angelo, T. A., & Cross, P. K. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers (Second ed.)*. San Francisco, CA: Jossey-Bass.

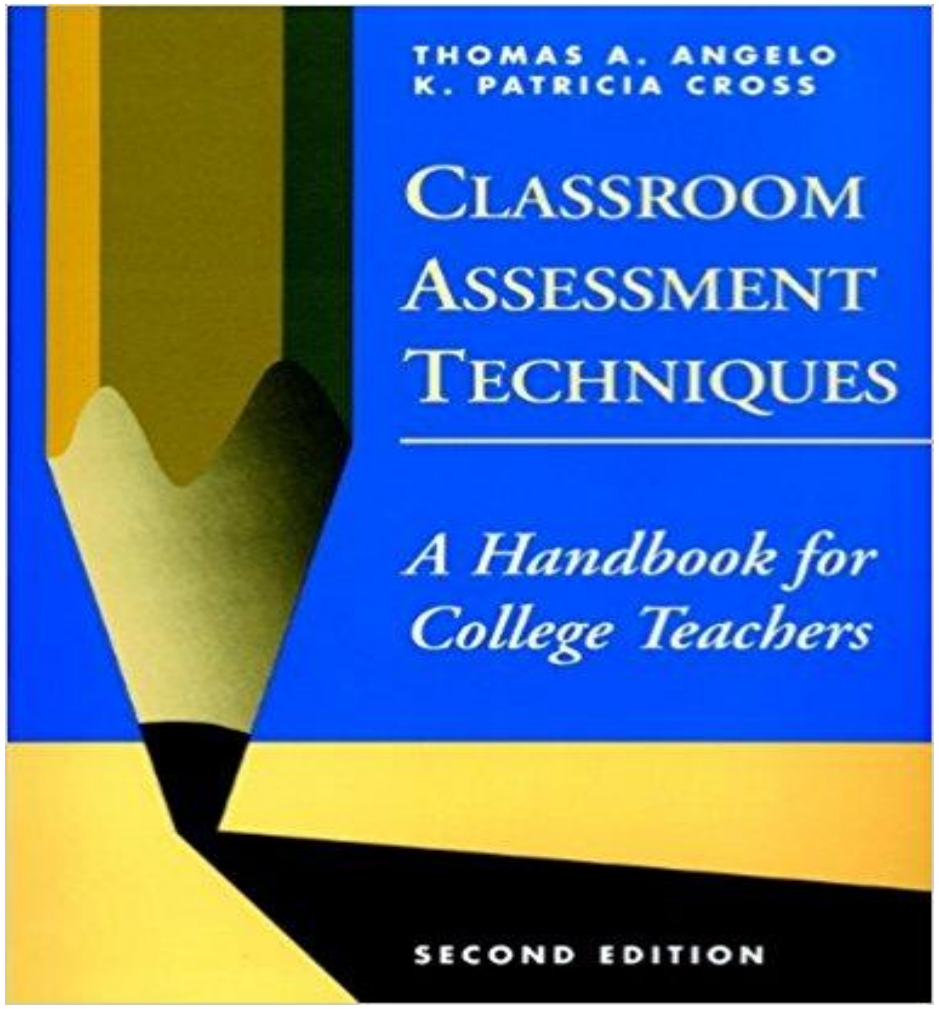
Classroom Assessment Techniques: https://cft.vanderbilt.edu/guides-sub-pages/cats/

Classroom Assessment Techniques

Questions:

- Give a five-to-ten-line summary of last night’s reading. Include two or three main ideas.
- What were three of the most important points from yesterday¹s discussion?
- If you were summarizing today¹s discussion for a friend who was absent, what two ideas do you think are the most essential?
- Define in your own words the term _____.
- Tell me three things wrong with this statement: _____.

Classroom Assessment Techniques



One-Minute Exercise

- Think of a course you will be teaching.
- Generate at least 3 ideas for how you might use classroom assessment techniques to support student learning in your course.

Part 3v

Student Response Systems

Student Response Systems

A classroom response system (aka, personal response system, student response system, or audience response system) is a set of hardware and software that facilitates teaching activities such as the following.

- Teacher poses a multiple-choice question to students.
- Students submits an answer “clicker”
- Teachers use software to collect answers and produce bar charts
- Teacher adjust instructional choices

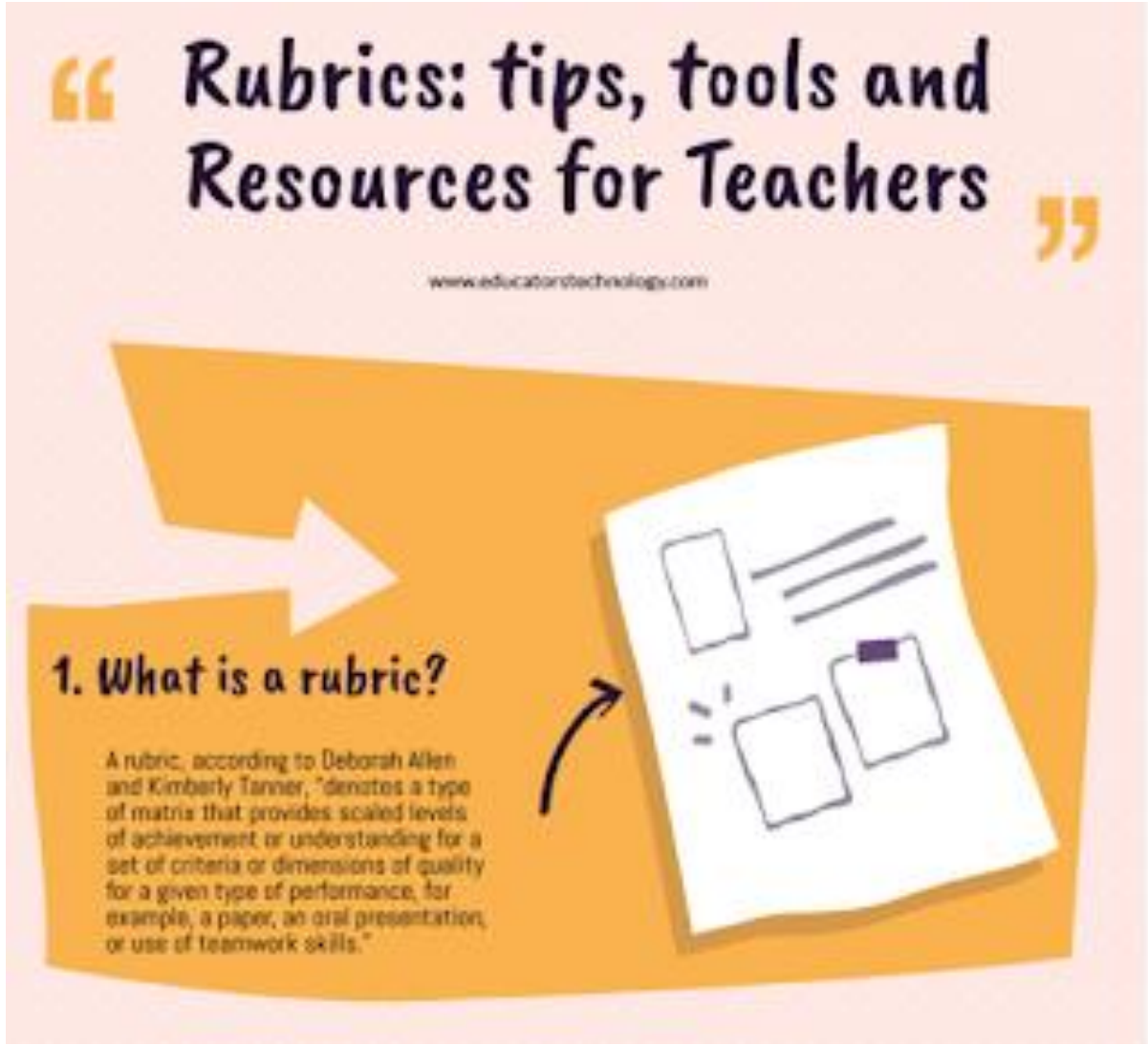
Classroom Response Systems (“Clickers”): https://cft.vanderbilt.edu/guides-sub-pages/clickers/

References: Student Response Systems

- Fies, Carmen, & Marshall, Jill. (2006). Classroom response systems: A review of the literature. *Journal of Science Education and Technology, 15*(1), 101-109. https://dx.doi.org/10.1007/s10956-006-0360-1
- Caldwell, Jane E. (2007). Clickers in the large classroom: Current research and best-practice tips. *CBE Life Science Education, 6*(1), 9-20. https://dx.doi.org/10.1187/cbe.06-12-0205
- Kay, R. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education, 53*(3), 819-827. https://dx.doi.org/10.1016/j.compedu.2009.05.001
- Hunsu, N. J., Adesope, O., & Bayly, D. J. (2016). A meta-analysis of the effects of audience response systems (clicker-based technologies) on cognition and affect. Computers & Education, 94, 102-119. https://dx.doi.org/10.1016/j.compedu.2015.11.013

Part 3vi

Rubrics



What do students produce on assignments and/or assessments?

Selection from a multiple choice question (right/wrong)

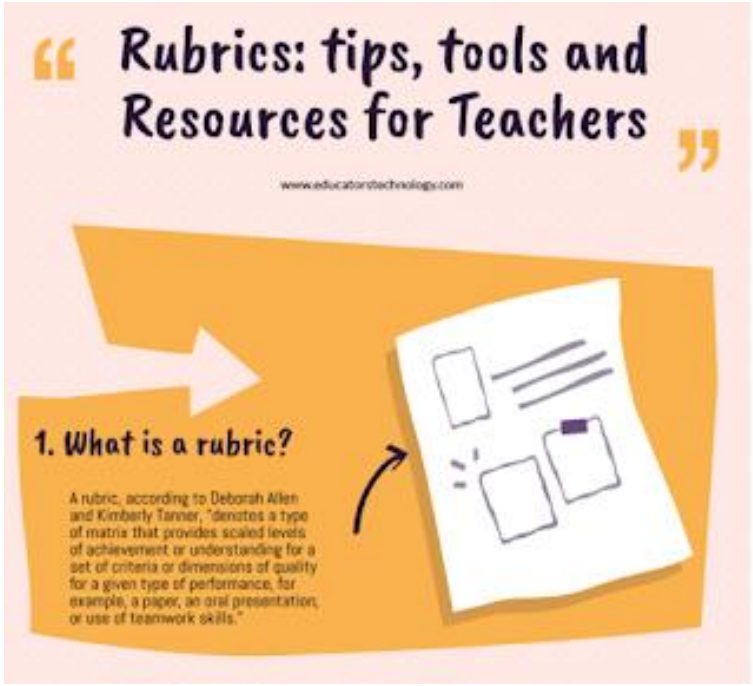
Short answers, e.g., number, few words (right/wrong)

Worked-out problem solution (?)

Short essay or paper or memo (?)

Long essay or paper (?)

Report (?)



As you move down the list, there is an increasing need for rubrics

Selection from a multiple choice question (right/wrong)

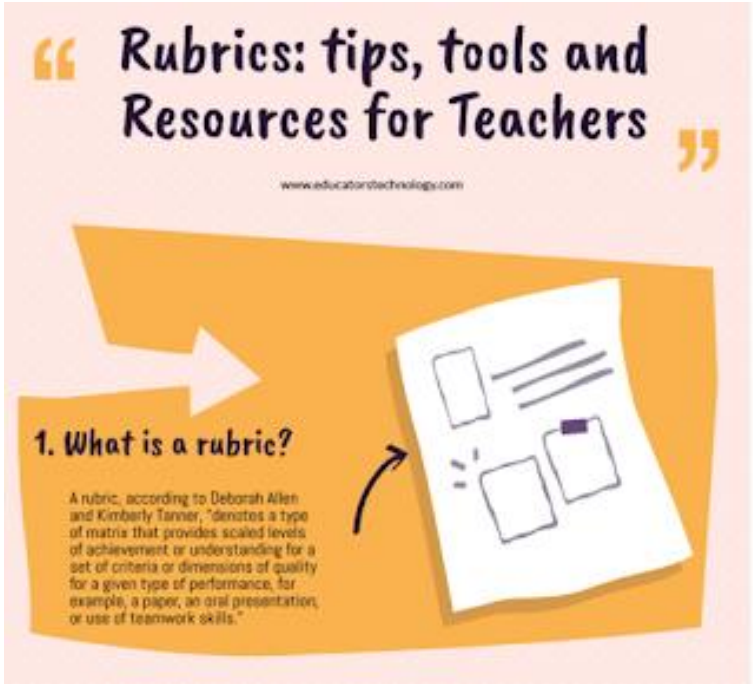
Short answers, e.g., number, few words (right/wrong)

Worked-out problem solution (?)

Short essay or paper or memo (?)

Long essay or paper (?)

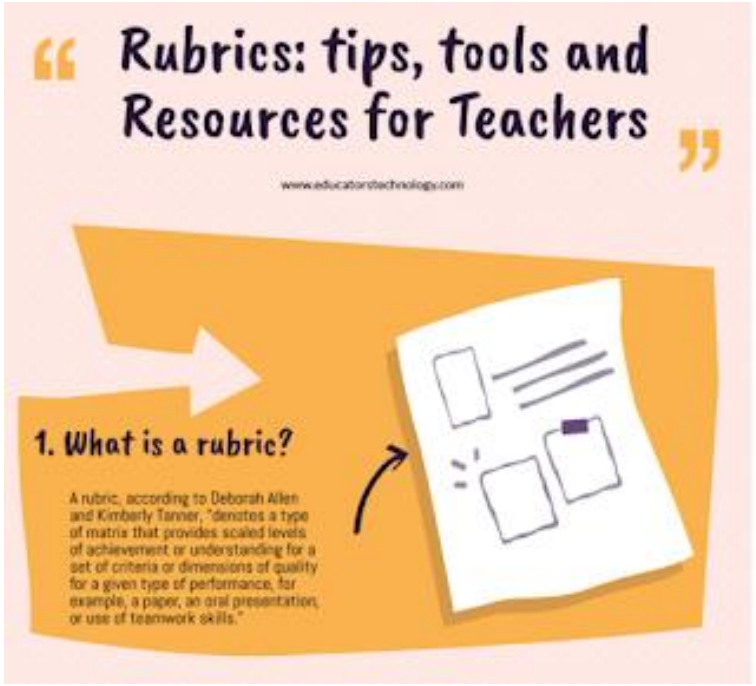
Report (?)



Rubrics

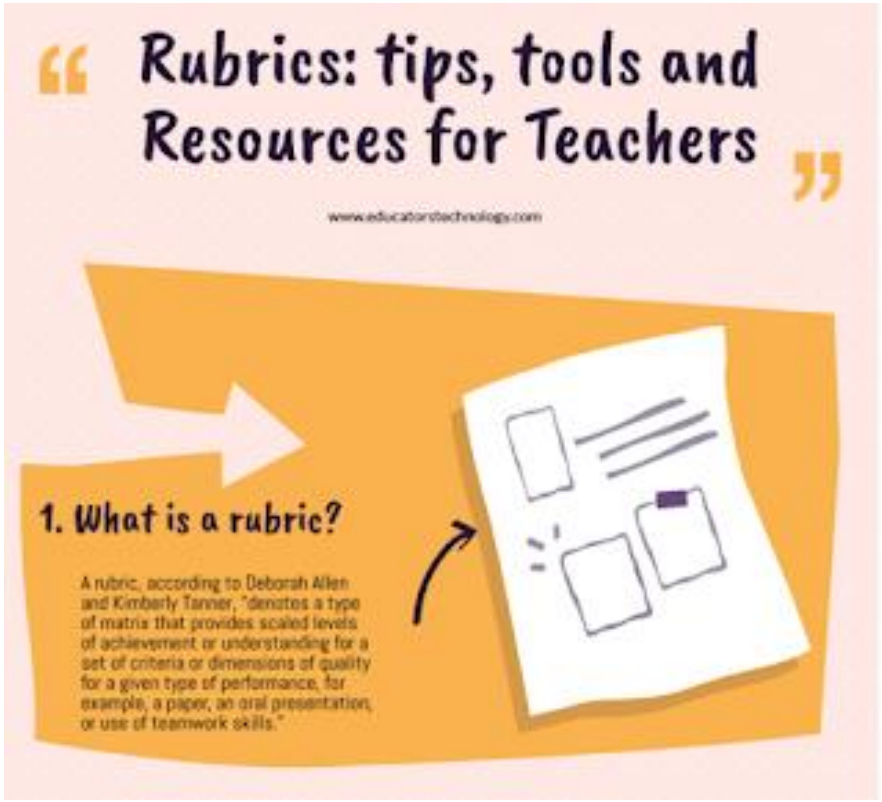
Designing a scheme for scoring complex student work products, e.g., design reports, extended papers, design projects, oral presentations, etc. can:

- Clarify expectations for student work
- Improve the quality of the work products
- Improve the quality of student learning
- Reduce the work in grading student work products



Developing Rubrics

- Faculty members should almost never start a rubric from scratch
- Faculty members should adapt an existing rubric they find after searching



Developing Instructional Rubrics: https://serc.carleton.edu/introgeo/assessment/conceptmaps.html

Developing Scoring Rubrics: https://serc.carleton.edu/introgeo/assessment/scorerubrics.html

Classroom Assessment Techniques, Scoring Rubrics: http://archive.wceruw.org/cl1/flag/cat/rubrics/rubrics1.htm

Developing Rubrics: Step 1

- Think of a course you teach
- Generate a learning outcome for the course at either the Analyze, Evaluate, or Create level (Bloom's Revised Taxonomy)

Developing Rubrics: Step 2

- For the learning outcome you generated in step 1, prepare an assignment (e.g., design project, major project, written report, engineering report, oral report, etc.) through which students would demonstrate their level of attainment with respect to the learning outcome.

Developing Rubrics: Step 3

For the assignment generate a list of characteristics that you would be looking for in the assignment that the students submit, e.g.:

- Reasonable list of design alternatives
- Thoroughness of engineering analysis
- Accuracy of engineering analysis
- Well-reasoned argument for their choice of a design alternative
- …

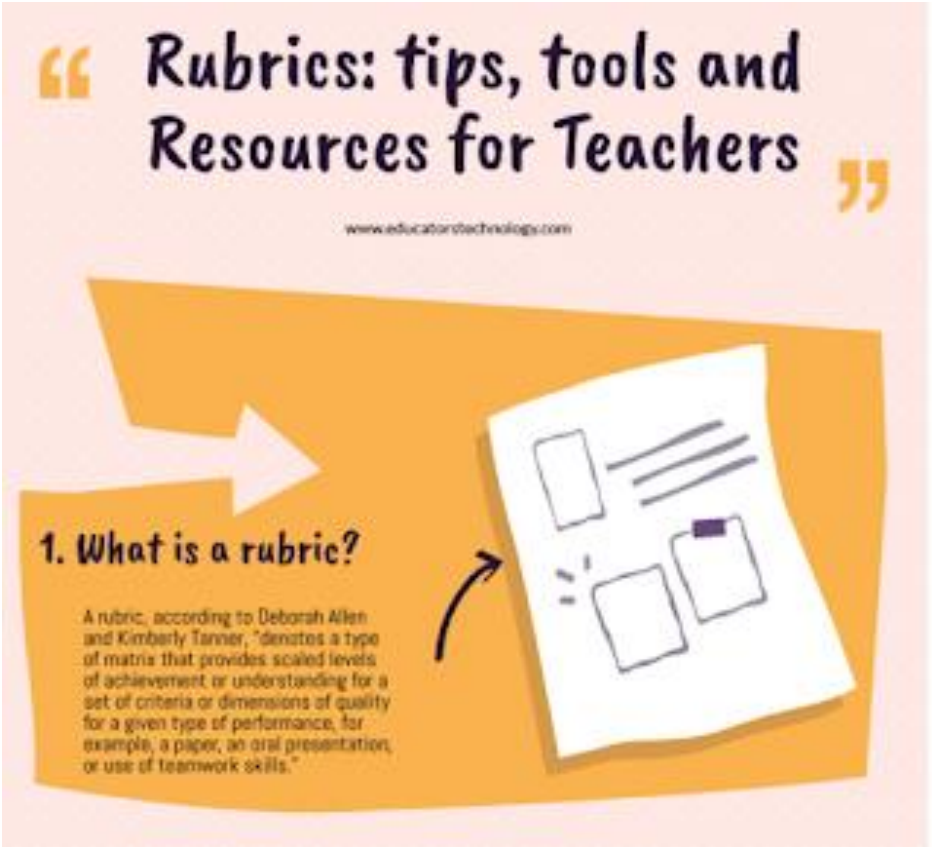
Developing Rubrics: Step 4

For each characteristic complete the row in the table on the next slide.

	1	2	3	4	5
Characteristic 1	Features that indicate a poor submission		Features that indicate a good submission		Features that indicate an excellent submission
Characteristic 2					
Characteristic 3					
Characteristic 4					
Characteristic 5					

Rubrics

A rubric is a coherent set of criteria for students' work that includes descriptions of levels of performance quality on the criteria.



http://www.ascd.org/publications/books/112001/chapters/What-Are-Rubrics-and-Why-Are-They-Important%C2%A2.aspx

What are some benefits of using rubrics?

Students

- Rubrics add meaning to grades and allow students to understand the expectations of their instructors.
- Rubrics provide feedback to students about what they have learned and what they have yet to learn.

Agreed Upon Values

- Rubrics allow stakeholders to discuss and determine agreed upon standards and values.

Data

- Rubrics promote consistent scoring.
- Rubrics provide rich, descriptive data that can be used to improve instruction.

Rubrics: Examples

Enhancing Learning by Improving Process Skills in STEM (ELIPSS) (http://www.elipss.com)

- **Critical Thinking:** Analyzing, evaluating, or synthesizing relevant information to form an argument or reach a conclusion supported with evidence.
- **Information Processing:** Evaluating, interpreting, manipulating, or transforming information.
- **Problem Solving:** Identifying, planning, and executing a strategy that goes beyond routine action to find a solution to a situation or question.
- **Teamwork:** Interacting with others and building on each other's individual strengths and skills, working toward a common goal.
- **Interpersonal Communication:** Exchanging information and understanding through speaking, listening, and non-verbal behaviors.
- **Written Communication:** Conveying information and understanding to an intended audience through written materials (paper, electronic, etc).
- **Management:** Planning, organizing, directing, and coordinating one's own and others' efforts to accomplish a goal.
- **Assessment:** Gathering information and reflecting on experiences to improve subsequent learning and performance.
- **Metacognition:** Thinking/reflecting about one's thinking and how one learns, and being aware of one's knowledge.

VALUE Rubrics - Association of American Colleges & Universities (AAC&U)

Intellectual and Practical Skills

- Inquiry and analysis
- Critical thinking
- Creative thinking
- Written communication
- Oral communication
- Reading
- Quantitative literacy
- Information literacy
- Teamwork
- Problem solving

Personal and Social Responsibility

- Civic engagement—local and global
- Intercultural knowledge and competence
- Ethical reasoning
- Foundations and skills for lifelong learning
- Global learning

Integrative and Applied Learning

- Integrative learning

VALUE Rubrics: https://www.aacu.org/value-rubrics

Engineering Design Rubric: Problem Definition

Rubric Element	Below Minimum (B)	Ideas (I)	Connections (C)	Extensions (E)
Stakeholder Needs	Missing or trivial identification and consideration of stakeholder needs.	Significant stakeholders are identified with nominal description.	All relevant stakeholders are identified and their needs are well defined.	All relevant stakeholders are identified with clear descriptions, relevance, and impact of their needs.
Problem Statement	Missing or incomplete statement that leaves ambiguity in the problem.	Cursory description outlines key ideas, but leaves some uncertainty.	Clear and complete statement that scopes the problem and does not predetermine the solution.	Clear, insightful, and focused statement elegantly distills the problem in concise language.
Design Criteria and Specifications	Missing, trivial, vague or unrelated criteria or constraints.	Simplistic criteria and constraints with some relevance to stakeholder needs.	Specific and measurable criteria and constraints developed from research and stakeholder needs.	Comprehensive, detailed and precise criteria and constraints logically developed from analysis of research and stakeholder needs.

Lanzinger, N. & Strong, D. S. (2016). Designing rubrics to assess engineering design, professional practice, and communication over three years of study. Paper presented at the Canadian Engineering Education Association Conference. Retrieved from https://ojs.library.queensu.ca/index.php/PCEEA/article/view/6509/6057

Engineering Design Rubric: Final Report Rubric

Report Element	Subsection	Level			
Stakeholder Needs Analysis	• Determination, assessment, relevance of stakeholders and their needs	B	I	C	E
Problem Statement	• Clarify and Concision • Inclusion of key "problem' details, captured in a brief summary	B	I	C	E
Constraints and Assumptions	• Project scope is well defined with clear constraints and assumptions • Logic, reasoning, and justification suitable for project topic	B	I	C	E
Design Criteria and Specifications	• Clear description of functional, aesthetic, and other requirements • Comprehensiveness, detail, and precision appropriate to project topic • Reader clearly understands outcomes required for successful solution	B	I	C	E

Lanzinger, N. & Strong, D. S. (2016). Designing rubrics to assess engineering design, professional practice, and communication over three years of study. Paper presented at the Canadian Engineering Education Association Conference. Retrieved from https://ojs.library.queensu.ca/index.php/PCEEA/article/view/6509/6057

Engineering Design Rubric: Final Report Rubric

Report Element	Subsection	Level			
Stakeholder Needs Analysis	• Determination, assessment, relevance of stakeholders and their needs	B	I	C	E
Problem Statement	• Clarity and concision of key project details • Establishment of a clear scope and objectives, concisely stated	B	I	C	E
Constraints and Assumptions	• Logic, reasoning, and justification • Assessment of validity of assumptions	B	I	C	E
Design Criteria and Specifications	• Clear description of functional, aesthetic, and other requirements • Value proposition in terms of monetary or non-monetary value to the client (e.g. market, productivity, cost reduction, customer recognition, etc.) • Comprehensiveness, detail, and precision appropriate to project topic • Reader clearly understands outcomes required for successful solution	B	I	C	E

Lanzinger, N. & Strong, D. S. (2016). Designing rubrics to assess engineering design, professional practice, and communication over three years of study. Paper presented at the Canadian Engineering Education Association Conference. Retrieved from https://ojs.library.queensu.ca/index.php/PCEEA/article/view/6509/6057

Engineering Design Process Assessment Rubric

Phase 1: Problem Definition: What is the evidence that the student can identify and define a problem in a way that can be solved in an engineering design process?	**Advanced**	**Proficient**	**Developing**	**Beginning**
Problem Identification: I can identify the problem (or question or need) clearly, including the client, user, and other stakeholders	• Problem is relevant and important in context of the assignment, and considers issues of social, economic, or environmental equity. • Problem is specific, challenging, and can be investigated given available resources. Root causes of problem have been identified and explored. • Stakeholders and local context are clearly identified and actively involved in problem identification.	• Problem is relevant and important in context of the assignment. • Problem is specific and can be thoroughly investigated given available resources • Stakeholders and local context are clearly identified and considered in problem identification	• Problem is relevant in context of the assignment. • Problem is specific enough to guide initial investigation • Stakeholders and local context are vaguely identified or superficially considered	• Problem's relevance or importance is unclear • Problem is too broad or narrow in scope to allow for adequate investigation • Stakeholders and local context are not identified or considered
Criteria Prioritization: I can identify and prioritize constraints and criteria to reflect needs and preferences of clients, users, and other stakeholders.	• Constraints are relevant, objective, testable, and expand scope of project. • Criteria are relevant and based on expressed and anticipated stakeholder preferences. • Protocols are used effectively to justify prioritization of criteria.	• Constraints are relevant, objective and testable. • Criteria are relevant and based on expressed stakeholder preferences. • Clearly justifies prioritization of criteria.	• Constraints are relevant but subjective in nature. • Criteria are relevant and weakly based on stakeholder preferences. • Weakly justifies prioritization of criteria.	• Constraints are vague and/or not relevant to the problem. • Criteria are vague and/or not relevant to the stakeholder preferences. • Does not prioritize or does not justify prioritization of criteria.

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Engineering Design Process Assessment Rubric

Phase 2: Design Exploration (Divergent): What is the evidence that the student can identify and thoroughly explore a variety of possible solutions and select an optimal design concept.	**Advanced**	**Proficient**	**Developing**	**Beginning**
Expansion: I can use brainstorming techniques to generate a broad range of possible design concepts	• Describes multiple viable design concepts based on initial testing data, reverse engineering, and/or new research prompted by one of the above.	• Describes multiple viable design concepts with scientific or engineering justification.	• Describes multiple viable design concepts without articulated scientific or engineering principles or a single solution based on articulated scientific or engineering principles.	• Describes only a single design concept based on partial or missing articulated scientific or engineering principles.
Exploration: I can explore promising solutions thoroughly through research, modeling, mock-ups, and experimentation to further inform design concepts	• Considers multiple metrics that align well with each criterion and constraint and justifies selection of the most valid metrics. • Documents preliminary testing data and/or research that is relevant to differentiating design concepts against multiple high-priority criteria.	• Establishes metrics that align well with the criteria and constraints. • Documents preliminary testing data and/or research that is relevant to differentiating design concepts against highest priority criterion.	• Establishes metrics that are weakly aligned with the criteria and constraints. • Documents preliminary testing data and/or research that is unlikely to differentiate design concepts against highest priority criterion.	• Establishes metrics that are poorly aligned with the criteria and constraints. • Documents minimal testing data and/or research, or is irrelevant to design concepts.
Design selection: I can compare a range of design concepts, and select a preliminary design that best meets the identified constraints and criteria	• Deliberately and effectively uses initial testing, data and/or research to objectively support preliminary design selection • Defends preliminary design choice against other concepts in light of criteria and constraints (trade-offs) using an appropriate objective tool (e.g. decision matrix).	• Deliberately uses initial testing, data and/or research to subjectively support preliminary design selection. • Defends preliminary design choice against other concepts in light of criteria and constraints (trade-offs).	• Uses data unsystematically for preliminary design selection. • Selects preliminary design based on criteria that are poorly aligned with criteria or constraints.	• No data collected to support preliminary design selection. • Evidence for preliminary design choice not logical or unfounded (choices made without rationale, or based on “favorite” concepts)

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Engineering Design Process Assessment Rubric

Phase 3: Design Optimization (Convergent): What is the evidence that the student can methodically improve an identified design concept into an effective solution?	**Advanced**	**Proficient**	**Developing**	**Beginning**
Design Iteration: I can optimize a selected preliminary design using an iterative testing process.	• Uses deliberate and effective iterative modifications (e.g. component testing) to characterize performance. • Justifies detailed final design using objective performance data from iterative testing.	• Uses deliberate iterative modifications (e.g. component testing) to characterize performance. • Justifies detailed final design using objective performance data from iterative testing.	• Uses unsystematic iterative modifications (e.g. component testing) to characterize performance. • Testing data is not sufficient to support detailed final design.	• Makes no iterative modifications to characterize performance. • Uses no data from iterative testing to support detailed final design.
Prototype development: I can demonstrate form and functionality of the design by creating a working prototype (e.g. working model, component, computer simulation).	• Prototype meets all constraints. • Prototype functionality exceeds expectations of detailed final design. • Prototype effectively communicates the form of the detailed final design with professional level quality.	• Prototype meets all constraints. • Prototype functionality aligns clearly with detailed final design. • Prototype effectively communicates the form of the detailed final design, and exhibits quality/craftsmanship.	• Prototype meets most but not all constraints. • Prototype functionality approaches expectations of detailed final design. • Prototype roughly communicates the form of the detailed final design.	• Prototype meets few constraints. • Prototype is insufficient to demonstrate basic functionality of detailed final design. • Prototype does not communicate the basic form of the detailed final design.

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Engineering Design Process Assessment Rubric

Phase 4: Design Communication: What is the evidence that the student can clearly communicate the detailed final design to an external audience?	**Advanced**	**Proficient**	**Developing**	**Beginning**
Communication: I can create a design documentation package that uses multiple representations to clearly explain the detailed final design.	• Design documentation is appropriately detailed and structured for the intended purpose and audience; extraneous information has been removed. • Documentation includes tolerances for all necessary specifications. • Documentation is polished and professional.	• Design documentation is appropriately detailed and structured for the intended purpose and audience. • Documentation is neat and includes all necessary specifications for assembly and/or operation. • Documentation is well-organized, professional, and free of mechanical errors.	• Design documentation is detailed but may not be optimized for the designated purpose. • Documentation is neat and includes most of the key parameters for assembly and/or operation. • Documentation is organized, neat, and contains few mechanical errors.	• Design documentation is not appropriate for the designated audience. • Documentation lacks crucial information. • Documentation requires significant editing and/or formatting.
Justification: I can explain the benefits and weaknesses of the design, including opportunities, tradeoffs and ideas for further improvement	• Communicates the design's strengths and limitations relative to competitor benchmarks and other design options. • Evaluates design as well as opportunities and tradeoffs in light of criteria and constraints, and defends the validity of metrics used. • Recommends design improvements which are supported by objective evidence or data.	• Communicates the design's strengths and limitations relative to other design options. • Evaluates design as well as opportunities and tradeoffs in light of criteria and constraints. • Recommends design improvements which are supported by subjective evidence.	• Communicates the design's strengths relative to other design options. • Evaluates design based on criteria and constraints. • Recommends design improvements; no evidence is cited to support these recommendations.	• Does not consider other design options. • Does not cite the criteria and constraints in evaluation of design. • No suggestions for improvement are offered.

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Engineering Design Process Assessment Rubric

Reflection: What is the evidence that the student can deeply reflect on performance, growth as a learner and ability to apply this in the future? **Know:** Explains goals, purpose, and academic skills/content of project **Do:** Explains process, decisions, engineering practices and leadership skills used **Reflect:** Describes the impact of project on self, future and growth as an engineer	**Advanced**	**Proficient**	**Developing**	**Beginning**
I can explain the purpose for doing this project, in terms of content understanding and academic skills	• Reflection clearly describes, in students' own words, key understandings and skills from the project, and connects far reaching or unanticipated content.	• Reflection clearly describes, in students' own words, key understandings and skills from the project.	• Reflection only partially identifies the key understandings and skills from the project or simply paraphrases teacher descriptions.	• Reflection misidentifies key understandings and skills from the project.
I can explain how I used the engineering design process effectively in this project, including engineering practices (leadership skills?)	• Reflection clearly connects project tasks to design process and engineering practices, and relates tasks and practices to divergent real-world examples.	• Reflection clearly connects project tasks to design process and references specific engineering practices.	• Reflection weakly connects project tasks with design process and engineering practices.	• Reflection does not explicitly connect project tasks with design process or engineering practices.
I can describe the impact of the project on my growth as a learner, as an engineer, and as a member of society	• Reflection describes specific skills and knowledge developed as a result of the project, and connects to personal interests/goals and societal needs/goals.	• Reflection describes specific skills and knowledge developed as a result of the project, and connects to personal interests and goals.	• Reflection describes specific skills and knowledge developed as a result of the project, weakly tied to personal growth.	• Reflection vaguely describes specific skills or knowledge without recognizing personal growth.

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Rubric Resources

- VALUE Rubrics – American Association of Colleges and Universities
  - https://www.aacu.org/value-rubrics
- ELIPSS Rubrics
  - http://www.elipss.com/resources.html
- Using Rubrics
  - https://www.cte.cornell.edu/teaching-ideas/assessing-student-learning/using-rubrics.html
- Rubric Library
  - http://www.fresnostate.edu/academics/oie/assessment/rubric.html
- Sample Rubrics
  - http://course1.winona.edu/shatfield/air/rubrics.htm
- Create Rubrics for your Project-Based Learning Activities
  - http://rubistar.4teachers.org/index.php

Parimal and Pramod Chaudhari
Centre for Learning and Teaching

Indian Institute of
Technology Bombay

Part 3vii

Designing Exams to Maximize Learning

Designing Exams to Maximize Learning

- Test on what you teach
- Consider handing out a study guide one to two weeks before each test
- Minimize speed as a factor in performance on tests
- Always work out a test from scratch when you have what you think is the final version, then revise it to eliminate the flaws you discover and try it again
- Set up multiple-part problems so that the parts are independent
- Design 10–15% of the test to discriminate between A-level and B-level performance

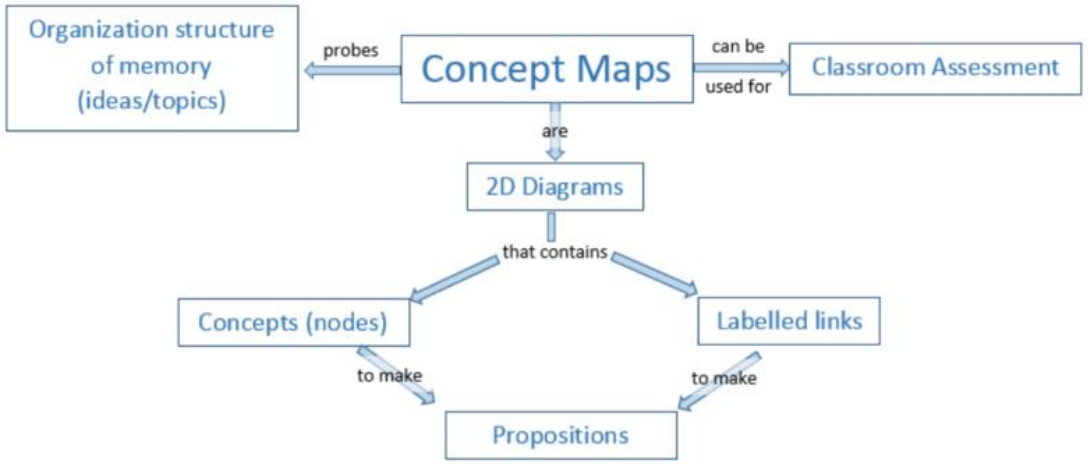
Felder, R. M. (2002). Designing tests to maximize learning. *Journal of Professional Issues in Engineering Education and Practice, 128*(1), 1-3.

Designing Exams to Maximize Learning

- Be generous with partial credit on time-limited tests for work that clearly demonstrates understanding and penalize heavily for mistakes on homework, where students have time to check their work carefully.
- Don’t deliberately design tests to make the average grade 60 or less
- If you give a test on which the grades are much lower than you anticipated and you believe some of the responsibility is yours, consider making adjustments
- If you are teaching a large class and use teaching assistants to grade tests, take precautions to assure that the grading is consistent and fair
- Institute a formal procedure for students to complain about test grades

Felder, R. M. (2002). Designing tests to maximize learning. *Journal of Professional Issues in Engineering Education and Practice, 128*(1), 1-3.

Concept Map Exercise



Without looking at your notes or slides, sketch a concept map to organize what you remember about the different assessment methods and how you connect them.

Minute Paper

- Write brief answers to the following questions:
  - What is most valuable or helpful about assessment of student learning?
  - What is the “muddiest or most confusing point” about assessment of student learning?

Part 4

Course Assessment Plans

Course Assessment Plans

	Learning Outcome No. 1	Learning Outcome No. 2	...	Learning Outcome No. N
Week 1	• How will LO #1 be assessed? • What feedback will you provide?	• How will LO #2 be assessed? • What feedback will you provide?		• How will LO #N be assessed? • What feedback will you provide?
Week 2				
...				
Week k				

Course Assessment Plans
Learning Incomes

- Will you prepare a set of learning incomes to articulate your expectations for what students should be able to do when they start your course?
- Will you assess student performance with respect to your learning incomes at the start of the course?
  - Will you be using a background knowledge probe?
  - Will you be using concept inventories?

Course Assessment Plans
Questions for Each Learning Outcome

- How will LO #1 be assessed?
  - Will you be using concept maps?
  - Will you be using concept questions?
  - Will you be using minute papers?
  - Will you be using other classroom assessment techniques?
  - Will you be using homework problems? Exams?
  - Will you be using memos, reports, design challenges, etc. for which rubrics would be very helpful?

An assessment example

Christian Schwartz

Mechanical Engineering Iowa State University

URL: https://www.engineering.iastate.edu/people/profile/cris1/

Email: cris1@iastate.edu

Table of Learning Outcomes Course Topics	Level 1 Calculate/Identify	Level 2 Apply/Analyze	Level 3 Evaluate/Design
1. Functional Decomposition			
2. Material Transitions **Transition modes: (i) yielding, (ii) fracture, (iii) deformation, (iv) buckling** **•Concepts of failure** **•Factor of safety** **•Strength**			
3. Stress **Normal stress: engineering vs. true** **•Shear stress** **•Stress concentration**			
4. Strain **Normal strain: engineering vs. true** **Shear strain**			
5. Stress vs. strain behavior **•Elasticity** **•Plasticity** **•Viscoelasticity** **•Thermoelastic behavior**			
6. Multiaxial loading behavior **•Principal stress** **•Mohr's Circle** **•Principal strain**			
7. Specific geometry behavior **Beams** **bending** **shear** **torsion** **Thin wall objects**			

Course Assessment Plan Overview

- There are 21 learning outcomes altogether.
- Level 1 learning outcomes (calculate and/or identify) are assessed through homework problems and quizzes. Students could check off a cell if they demonstrated attainment through some combination of homework problems and quizzes.
- Level 2 learning outcomes (apply and/or analyze) are assessed through homework problems and quizzes. Students could check off a cell if they demonstrated attainment through some combination of homework problems and quizzes.
- Level 3 learning outcomes (evaluate and/or design) are assessed only through exams. Students could check off a cell if they demonstrated attainment through on an exam problem designed to assess the learning outcome for that cell.

Grading and assessment of student learning are different.

Connecting Learning Outcomes to Course Grades

- Dr. Christian Schwartz (Iowa State University) developed the following approach to evaluating student learning that connects course learning outcomes to grades.
- You will be assigned a letter grade based upon the number and level of LO's that you attain in the LO matrix (next slide). Letter grades will be assigned as follows:
  - A: At least 4 level-3 outcomes attained
  - B: At least all level-2 outcomes attained
  - C: At least 4 level-2 outcomes attained
  - D: At least all level-1 outcomes attained
  - F: Less than 4 level-1 outcomes attained

Exercise: Course Assessment Plans

- Think of a course you will be teaching.
- What steps would you take in developing a course assessment plan for this course?

Questions?