Case Study: Making the Invisible Visible in Physics

Context of the Problem: To assess physics students' entering knowledge state of mathematics and physics concepts, as well as to continue to monitor students' future knowledge and understanding of these concepts, physics faculty often use concept inventories, tests designed to identify and classify errors in students' thinking. Typically, results of these concept inventories for matriculating students have documented that entering students do not have a coherent understanding of physics and mathematical concepts. According to Halloun and Hestenes, students bring with them erroneous kinds of ideas about physics concepts such as force, or weight, or buoyancy, that interfere with their ability to correctly learn physics content. Specifically, students form their own "personal understanding " or "initial knowledge state" (1984, p. 1043) that inhibits them from developing more complex knowledge as they move into subsequent courses. Initially, they carry qualitative, common sense beliefs that form their own personal system of beliefs and intuitions. In turn, this system functions for them as a common sense theory of the physical world through which they continue to interpret their past and new experiences. This belief system effects students' future performance in physics, often interfering with what students actually hear in a physics course and then deterring them from making progress in their future courses despite faculty efforts to position them to restructure their personal learning. Concept inventories predictably show some of the kinds of misconceptions and understanding that entering first year students demonstrate. Historically, lectures, demonstrations, laboratories, exercises and models have been ineffective in restructuring entering physics students' initial knowledge states and belief systems. For example, when presented with different scenarios that can be explained by the same underlying concept, students often apply different conceptual explanations, including some that have been proven historically incorrect.

What's the Driving Question ? Recognizing that conventional teaching methods, laboratories, lectures, demonstrations, for example, were not typically successful in correcting students' conceptual misunderstandings, Carl Wieman and colleagues from the Physics Department at the University of Colorado asked: "How can we effectively restructure entering students' naïve understanding?" Wieman recalled how consistently his diverse public lecture audiences learned the physics in his talks through the simulations he incorporated. He recalls:

> …sims would be the primary thing people would remember from my talk, and based on their questions and comments, it appeared that they consistently learned the physics represented in the sims. What was particularly remarkable was that my audiences found the sims engaging and educationally productive whether the talk was a physics department colloquium, or a presentation to a middle school class. I had never seen an educational medium able to effectively address such a wide range of backgrounds, and so when I received support through the NSF Distinguished Teaching Scholars program in 2001, I used it to start the PhET project to systematically develop and research interactive sims for teaching physics (Wieman, Adams, and Perkins, October, 2008, 682-683).

What's the Solution? With initial supportf from the National Science Foundation, Wieman and his tearm turned to research on learning, specifically How The Mind Works (Bransford, 2000) to learn more about the kinds of obstacles that were impeding student learning. Drawing on these sources and his experiences with audiences in his talks, he and his team designed initial sets of interactive computer simulations that allowed each student to "see" what experts know and positioned each student to engage with online scenarios as a strategy for them to learn concepts as well as restructure erroneous naïve understanding. The design of every simulation is an iterateive process that includes student "think-aloud" interviews to learn about and verify that the interface is intuitive and that students learn only correct science from the simulations. The attached figure represents an opening screen of one of many interactive computer simulations designed to promote students' learning about electricity and circuits principles and concepts under the PhET Interactive Simulations Project (PhET Project) (PhET. Colorado.edu http://phet.colorado.edu/simulations/sims.php?sim=Circuit_Construction_Kit_DC_Only).

Interactive computer simulations, such as the one for electricity and circuits, position students to arrive at their own explanation and application of concepts, restructuring erroneous learning as well as reinforcing learning. Periodic use of concept inventories documents that students carry their new restructured learning into future courses so that they build coherent conceptual knowledge. These inventories function as a way to diagnose students initially as well as to assess their future performance to assure that they have corrected misconceptions or misbeliefs and are building on their restructured learning. Identifying obstacles in student learning, including students' inability "to see" what physics faculty know or understand, such as visualizing a standing wave on the string of a violin, and positioning students to become engaged in their learning through interaction with real-life phenomena and scientific concepts in real time has led to an alternative way to ground and advance students' conceptual learning in physics (Wieman, Perkins, and Adams, April,2008).

Works Cited

Halloun, I.A., and Hestenes, D. (November, 1985). The Initial Knowledge State of College Physics Students. *American Journal of Physics*. pp. 1043-1048.

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Wieman, C.E., Perkins, K.K., and Adams, W.K. (April,2008). Oersted Medal Lecture 2007: Interactive Simulations for Teaching Physics: What Works, What Doesn't and Why. *American Journal of Physics*. Vol 76, Issue 4, pp. 393-399.

Appendix C: Action Words for Bloom’s Taxonomy

Knowledge	Understand	Apply	Analyze	Evaluate	Create
define	explain	solve	analyze	reframe	design
identify	describe	apply	compare	criticize	compose
describe	interpret	illustrate	classify	evaluate	create
label	paraphrase	modify	contrast	order	plan
list	summarize	use	distinguish	appraise	combine
name	classify	calculate	infer	judge	formulate
state	compare	change	separate	support	invent
match	differentiate	choose	explain	compare	hypothesize
recognize	discuss	demonstrate	select	decide	substitute
select	distinguish	discover	categorize	discriminate	write
examine	extend	experiment	connect	recommend	compile
locate	predict	relate	differentiate	summarize	construct
memorize	associate	show	discriminate	assess	develop
quote	contrast	sketch	divide	choose	generalize
recall	convert	complete	order	convince	integrate
reproduce	demonstrate	construct	point out	defend	modify
tabulate	estimate	dramatize	prioritize	estimate	organize
tell	express	interpret	subdivide	find errors	prepare
copy	identify	manipulate	survey	grade	produce
discover	indicate	paint	advertise	measure	rearrange
duplicate	infer	prepare	appraise	predict	rewrite
enumerate	relate	produce	break down	rank	role-play
listen	restate	report	calculate	score	adapt
observe	select	teach	conclude	select	anticipate
omit	translate	act	correlate	test	arrange
read	ask	administer	criticize	argue	assemble
recite	cite	articulate	deduce	conclude	choose
record	discover	chart	devise	consider	collaborate
repeat	generalize	collect	diagram	critique	collect
retell	give examples	compute	dissect	debate	devise
visualize	group	determine	estimate	distinguish	express
	illustrate	develop	evaluate	editorialize	facilitate
	judge	employ	experiment	justify	imagine
	observe	establish	focus	persuade	infer
	order	examine	illustrate	rate	intervene
	report	explain	organize	weigh	justify
	represent	interview	outline		make
	research	judge	plan		manage
	review	list	question		negotiate
	rewrite	operate	test		originate
	show	practice			propose
	trace	predict			reorganize
	transform	record			report
		schedule			revise
		simulate			schematize
		transfer			simulate
		write			solve
					speculate
					structure
					support
					test
					validate

Some Examples of Learning Outcome Statements in the Sciences, Social Sciences, and the Arts

Anthropology:

• Describe the breadth of anthropology and be able to characterize the range of anthropology's distinctive philosophical and methodological approaches with respect to other disciplines within the social sciences, natural sciences, and humanities.

• Describe the historical development and centrality of the "four-field approach" in American anthropology, with the ability to define each subdiscipline's contributions to the whole.

• Explain the basic processes of biological evolution and specifically, describe the evidence for humankind's descent from apes and the subsequent course of human evolution.

• Describe modern human biological diversity and articulate an informed position on the question of biological races of humans.

• Apply various methods of inquiry to anthropological research

* Apply quantitative methods in the analysis of data from all four sub-fields in anthropology

• Identify the wide range of past and present human biocultural systems, including ecological relationships, social and cultural organization, and ideology (belief systems).

• Think holistically and comparatively in describing human life-ways using non-ethnocentric methods.

• Assess the relative advantages and disadvantages of using archaeology as a method for elucidating culture history.

*Evaluate the use and misuse of analyses of quantitative data in anthropological research.

• Develop and articulate anthropological insights into contemporary issues of multiculturalism and diversity with reference to both past and present human biological and ethnic or cultural variation.

Biology:

- Recognize the relationship among structure, function, and process at all biological levels: molecular, cellular, organismal, population, community, and ecosystem.
- Describe and explain the major cellular processes in eukaryotes and prokaryotes.
- Describe the flow of genetic information, the chromosome theory of heredity, and the relationship between genetics and evolutionary theory.
- Use the principles of biological classification to examine the diversity of life and identify the phylogenetic relationships of the major groups of organisms
- Explain the principles of organismal evolution, including the role of natural selection
- Explain the ecological relationships between organisms and their environment.
- Demonstrate an ability to think critically and synthesize scientific information.
- Demonstrate an ability to apply mathematical and statistical approaches to interpreting biological information.
- Apply the scientific process, including designing and conducting experiments and testing hypotheses.
- Develop skills in the use of laboratory and field techniques commonly used in biology.
- Demonstrate the ability to read, understand, and critique scientific papers.
- Prepare oral and written reports in a standard scientific format.
- Abide by established scholarly and scientific ethics in biology.
- Demonstrate knowledge of the role of biological science in society
- Develop an awareness of the careers and professions available in the biological sciences.

Business Administration with a Major in Accounting:

Content:

- Develop facility in the use of terminology and concepts in the major areas of business: Information

Technology, Management, Accounting, Marketing, Economics, and Finance

- Identify issues and problems in accounting contexts
- Apply accounting principles to solve principles

Critical Thinking:

- Identify and analyze key elements that comprise business problems/opportunities
- Select and apply appropriate discipline frameworks to address business problems/opportunities
- Select and apply appropriate problem-solving techniques to business problems
- Integrate knowledge across business disciplines to formulate defensible strategic business decisions

Communication:

- Create and deliver effective oral presentations
- Develop effective written presentations
- Contribute effectively to group discussions

Integrity/Values

- Recognize legal and ethical problems that occur in business contexts
- Select and defend an appropriate ethical and legal course of action

Project Management

- Design and execute reasonable timelines for project completion
- Collaborate effectively with diverse individuals
- Manage appropriately to facilitate project completion

Geology:

Identify, describe, and classify earth materials, formations, and structures and interpret them in the context of geologic processes

Analyze and report quantitative geologic data collected in the field and laboratory

Read, write, present, and critically evaluate geologic reports, professional papers and maps

Synthesize information from a variety of disciplines to solve geologic problems

Graphic Design:

Apply critical thinking skills and coordinated technical skills using the latest computer software for visual problem solving and print and digital production.

Execute graphic solutions in print, digital, and multimedia areas for a selection of visual communication problems.

Conduct research by selecting and managing both traditional and non-traditional resources to inform decisions

Develop a personal conceptual framework for evaluating the relevance of a work, whether visual or verbal, to its larger cultural, social, or historic context

Mathematics and Formal Reasoning:

1. Interpret and apply quantitative information and/or mathematical analysis to obtain sound results and recognize questionable assumptions;
2. Understand major concepts and their applications;
3. Analyze and interpret formulae and quantitative information using appropriate technologies and abstract reasoning;
4. Understand and articulate how findings and ideas can be applied to explain phenomena and impact the larger society; and
5. Communicate quantitative information, analyses, etc. through appropriate written and/or oral means.

Physics:

1. Use appropriate computing tools to solve problems encountered in course work or in supervised study.
2. Synthesize appropriate concepts and methods from different courses in the solution of problems.
3. If working on a research project, perform a literature search, use appropriate computational or laboratory skills, and make an effective written or oral presentation of the results of the project.
4. Design and carry out experimental investigations, analyze data with appropriate treatment of errors and uncertainties, and form conclusions based on the data and analysis.
5. In speaking or writing, discuss ethical issues that relate to physics.

Physical Sciences and Life Sciences:

1. Use quantitative information and/or mathematical analysis to obtain sound results and recognize questionable assumptions;
2. Demonstrate understanding of the broad principles of science and the ways scientists in a particular discipline conduct research;
3. Make observations, understand the fundamental elements of experiment design, generate and analyze data using appropriate

quantitative tools, use abstract reasoning to interpret the data and formulae, and test hypotheses with scientific rigor;
4. Understand how findings and ideas in science can be applied to explain phenomena and events and influence the larger society;
5. Understand the role that human diversity plays in the practice and history of science;
6. Communicate about science using appropriate oral and written means; and
7. Demonstrate proficiency in the collection, interpretation, and presentation of scientific data.

<u>Psychology:</u>

The following text is excerpted from the full APA Report Undergraduate Psychology Major Learning Goals and Outcomes

Application of Psychology

4.1 Describe major applied areas of psychology (e.g., clinical, counseling. industrial, organizational, school, health).

4.2 Identify appropriate applications of psychology in solving problems, such as

a. the pursuit and effect of healthy lifestyles
b. origin and treatment of abnormal behavior
c. psychological tests and measurements
d. psychology-based interventions in clinical, counseling, educational, industrial organizations, community, and other settings and their empirical evaluation

4.3 Articulate how psychological principles can be used to explain social issues and inform public policy.

a. Recognize that sociocultural contexts may influence the application of psychological principles in solving social problems
b. Describe how applying psychological principles can facilitate change

4.4 Apply psychological concepts, theories, and research findings as these relate to everyday life.

4.5 Recognize that ethically complex situations can develop in the application of psychological principles.

__Sociology:__

Demonstrate a working knowledge of the core concepts of sociology (social structure; culture; social stratification and inequality; race, ethnicity, and gender; and globalization).

Demonstrate a working knowledge of the nature, methods, and critical thinking skills in qualitative and quantitative research methodologies in the field.

Apply their understanding of sociology to their professional, personal and civic lives.

Develop an appreciation for the rich diversity within and between societies and cultures.

Non-majors in Sociology will be able to:

Demonstrate familiarity with sociological principles and practices.

Evaluate the impact of sociology on society and sociologically-related issues.

Theater:

- execute the four fundamentals of play directing: play analysis, communication with actors, design and production, interpretation and style;
- identify important practices, playwrights, and plays in the history of theatre and articulate the relationship between theatre and the culture within which it exists;
- construct a theoretical argument using historical information;
- create and present a project demonstrating expertise in a chosen area: performance, directing, theatre in education or community engagement, design or research;
- develop and demonstrate a standard audition packet (performance track) or portfolio (technical theatre track) as defined by URTA (performance track).

BUSINESS ADMINISTRATON
COMPETENCIES/EXPECTED OUTCOMES
FOR THE COMMON PROFESSIONAL COMPONENT

Sample Pages from Business Administration Map	Macro-Economics	Micro-Economics	Microcomp App for Bus	Writing for Bus	Pre-Calc (Bus)	Intro to Bus	Bus Statistics	Prin Mgmt	Prin Mktg	International Bus	Prin Acctg I	Prin Acctg II	Bus Law I	Mgl Finance	Bus Poli
I=Introduce; R=Reinforce; E=Emphasize	**Econ 207**	**Econ 208**	**CS 214**	**Eng 200**	**Math 1165**	**Busi 201**	**Busi 203**	**Busi 211**	**Busi 231**	**Busi 241**	**Busi 251**	**Busi 252**	**Busi 281**	**Busi 371**	**Busi 411**
Technology and Information Literacy															
Identify problem/topic						I		R						R	
Demonstrate familiarity with information resources and technologies						I		R						R	
Conduct search query						I		R						R	
Evaluate sources of information						I		R						R	
Computer Literacy															
Demonstrate computer literacy in preparation of reports and presentations			I						R					E	E
Demonstrate ability to use software application to solve business problems							I				R	R		E	
Conduct search queries through the use of the Internet						I		R	R					E	
Values Awareness															
Recognize ethical issues						I		R	R	R			E		E
Identify ethical issues						I		R	R	R			E		E
Identify theoretical frameworks that apply to corporate social responsibility						I		R	R	R			R	R	E
Translate ethical concepts into responsible behavior in a business environment						I		R	R	R				R	E
Develop values awareness						I		R	R	R					E
CONTENT-SPECIFIC COMPETENCIES ***Global Business Competencies***															
Demonstrate knowledge of contemporary social, economic, and political forces; their interrelationship; and their impact on the global business environment	I	I				I		R	R	RE				R	R
Identify the integration of global markets from both financial and product/service perspectives.						I			R	RE				R	R

BUSINESS ADMINISTRATON
COMPETENCIES/EXPECTED OUTCOMES
FOR THE COMMON PROFESSIONAL COMPONENT

Sample Pages from Business Administration Map	Macro-Economics	Micro-Economics	Microcomp App for Bus	Writing for Bus	Pre-Calc (Bus)	Intro to Bus	Bus Statistics	Prin Mgmt	Prin Mktg	International Bus	Prin Acctg I	Prin Acctg II	Bus Law I	Mgl Finance	Bus Poli
I=Introduce; R=Reinforce; E=Emphasize	**Econ 207**	**Econ 208**	**CS 214**	**Eng 200**	**Math 1165**	**Busi 201**	**Busi 203**	**Busi 211**	**Busi 231**	**Busi 241**	**Busi 251**	**Busi 252**	**Busi 281**	**Busi 371**	**Busi 411**
Incorporate diverse cultural perspectives into business decisions						I		R	R	RE					R
Accounting Competencies															
Understand the role of the accounting information system within an organization's overall information system											I	R		R	
Demonstrate knowledge of the accounting cycle and the ability to perform necessary procedures at each step of the cycle for both corporate and non-corporate entities											I	R			
Describe, prepare and interpret comparative financial statements using analytical techniques such as ratios and common-size statements											I	R		E	
Understand the differences between financial and managerial accounting															
Understand the role of managerial accounting analysis, control and planning of costs within the corporation											I	R			
Finance Competencies															
Integrate knowledge of economics, accounting, and quantitative analysis in the process of making financial decisions	I	I												IRE	
Access and interpret financial market data using both Internet and print sources						I		R	R	R				RE	
Apply basic computational techniques and/or spreadsheet software to solve financial problems							I				R	R		E	
Compute return and risk measures for basic financial assets (stocks and bonds)														I	
Analyze corporate financial statements to pinpoint strengths and weaknesses.											I	R		E	R

BUSINESS ADMINISTRATON
COMPETENCIES/EXPECTED OUTCOMES
FOR THE COMMON PROFESSIONAL COMPONENT

Sample Pages from Business Administration Map	Macro-Economics	Micro-Economics	Microcomp App for Bus	Writing for Bus	Pre-Calc (Bus)	Intro to Bus	Bus Statistics	Prin Mgmt	Prin Mktg	International Bus	Prin Acctg I	Prin Acctg II	Bus Law I	Mgl Finance	Bus Polic
I=Introduce; R=Reinforce; E=Emphasize	**Econ 207**	**Econ 208**	**CS 214**	**Eng 200**	**Math 1165**	**Busi 201**	**Busi 203**	**Busi 211**	**Busi 231**	**Busi 241**	**Busi 251**	**Busi 252**	**Busi 281**	**Busi 371**	**Busi 411**
Identify the impact of investment, financing and dividend policy decisions on the value of an enterprise														I	
Use financial tools for life decisions about items such as housing, credit, retirements, and investments														I	
Developed by Business Administration faculty at New Jersey City University															

GENERAL EDUCATION OUTCOMES
Natural Science Department

PHYSICS ASSESSMENT MAP

GENED SLO	Performance Measures	PHY 1000	PHY 2053	PHY 2054	PHY 2048	PHY 2049	PSC 1121	AST 1002
1. Be able to think critically	a. Identify the validity of collected data.		I L,T	E L	I L	E L		
	b. Use graphical and numerical methods to organize, analyze and interpret natural phenomena from collected data.		I L	E L	I L	E L		
	c. Use graphs, tables and charts to summarize, analyze and interpret information to solve problems.		I W	E T	I W	E T		I T
2. Demonstrate facility in written and oral communications	a. Speak clearly, project voice sufficiently, and use appropriate vocabulary.	E P	E C	M C	E C	M C	I C	
	b. Write effective Lab Reports and Project Reports	I P	E LR		E LR			I P
	c. Present information clearly in tables, charts and graphs.	I P	E LR		E LR			

Level of Attention	Method of Learning	Method of Assessment
I=Introduce	L=Laboratory Experiment	Written document using a scoring rubric
E = Emphasize	C = Class Discussion	Portfolio entry scored with scoring rubric
M = Master	LR = Lab Report	Exam or Quiz scored against benchmark
	P = Project	Oral Presentation using a scoring rubric
	T = Quiz or Test	Rising Junior Milestone Exam using rubric and benchmark score
	W = Homework	Other….

Coding for Curricular Mapping(Ohio State University: Pharmacy)

Connection Codes – Degree or level of connection between course and outcome.

Not Applicable or Level 0
Meaning that there is no relationship between the course and the outcome.

I – Introductory/Background or Level 1
There is an **indirect relationship** between the course and the outcome. The outcome itself is not the focus of the course but at least one element of the course serves as a building block to the achievement of the final outcome. For example, course elements may provide either the knowledge, skills or attitudes necessary for the ultimate achievement of the outcome.

M – Intermediate/transitional or Level 2
There is a **more of a direct relationship** between the course and the outcome than at Level 1. A mixture of course elements supports the final achievement of the outcome, but the final integration of the knowledge, skills, and attitudes necessary for its achievement is not accomplished in this course. For example, knowledge, skills and/or attitudes (at least 2 of the 3) required for the achievement of the outcome may be the focus of the course or course element, but the integration of all three is not.

E – Emphasized or Level 3
There is a **direct relationship** between the course and the outcome. At least one element of the course focuses specifically on the complex integration of knowledge skills and attitudes necessary to perform the outcome.

Pedagogy codes – How outcome is taught

L = Lecture
LD = Lecture/discussion
C = Cases – any type of problem based learning, learning applied to realistic scenarios
E = Experiential – actual practice of the outcome in a real or simulated environment, may include the use of live "subjects" (patients, patient actors, health care practitioner etc)
I = Independent study

Assessment codes – How the outcome is evaluated

B = building blocks – students are assessed primarily on their grasp of basics i.e. recall of information rather than their ability to apply and or synthesize that knowledge and/or skills and/or attitudes
A = Application/Synthesis – students are assessed on their ability to apply and synthesize knowledge and/or attitudes and/or skills. This includes simulated experiences
D = Demonstration – students demonstrate their abilities; they are assessed based on their ability to show mastery of the elements of the outcome. The "demonstration" may occur in either a simulated environment (e.g., OSCE or professional practice laboratory) or in realistic setting (e.g., patient care setting)

	Introductory Course	Research Methods	Advanced Content Course A	Laboratory / Practicum Course	Advanced Content Course B	Advanced Content Course C	Advanced Content Course D	Capstone Course
Content								
SLO 1	**Exam Questions**		**Exam Questions**		**Term Paper**			**Project Rubric**
SLO 2	**Exam Questions**				**Exam Questions**		**Exam Questions**	**Project Rubric**
SLO 3	**Exam Questions**	**Exam Questions**				**Exam Questions**		**Project Rubric**
SLO 4	**Exam Questions**	**Exam Questions**		**Lab Reports**			**Exam Questions**	**Project Rubric**
Critical Thinking								
SLO 5		**Term Paper**			**Exam Questions**			**Project Rubric**
SLO 6				**Exam Questions**				**Project Rubric**
Communication								
SLO 7		**Term Paper**		**Term Paper**				**Project Rubric**
SLO 8						**Term Paper**		**Project Rubric**
Integrity / Values								
SLO 9		**Term Paper**		**Term Paper**		**Term Paper**		**Project Rubric**
SLO 10								
Project Management								
SLO 11				**Peer Evaluations**				
SLO 12								**Project Rubric**

Taxonomy of Weaknesses, Errors, or Fuzzy Thinking

Types of Weaknesses, Errors, or Fuzzy Thinking	Identify context of errors or weaknesses	Identify possible causes with the assistance of students
1.For example*, conceptual, mathematical*, *analytical, computational, grammatical,fuzzy recall, procedural, linguistic,pattern discernment,interpretive,reasoning,inability to apply to new or unfamiliar contexts, etc.*		
2.		
3.		
4.		

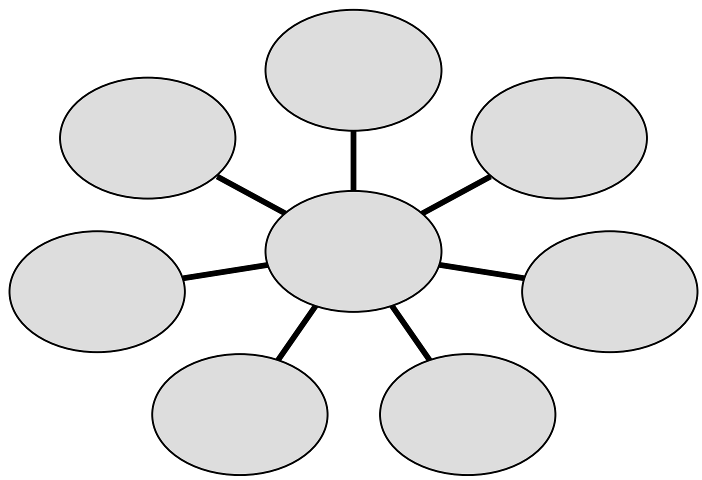
From Maki, P. (forthcoming, 2010). 2nd Ed. *Assessing for Learning: Building a Sustainable Commitment across the Institution*. Stylus Publishing, LLC.

Some Direct and Indirect Methods, including the Use of Technology,
from Peggy Maki from forthcoming (late 2010) New Edition of *Assessing for Learning,*
Stylus Publishing, LLC

- Test of knowledge of facts, processes, procedures, concepts, etc.
- Case Study/Problem that requires students to demonstrate how one has integrated outcome-based learning into his or her work
- Summary from homework assignment; summary after a segment of lecturing or other pedagogical method
- Description of what one already knows before movement into a new topic or focus
- Discussion of how one may have changed his or her understanding based on learning more about a topic or engaging in research on a topic
- Group work that emerges from material covered with self-analysis and analysis of others
- Team projects that emerge from material covered
- Self-reflection on what one does and does not understand
- Written assignment that explores a distinctive critical perspective or problem
- Critical incident response
- Representative disciplinary or professional work assignments
- Capstone Project
- Thesis
- Collaborative Project
- Research Project
- Interpretation of unidentified pieces of discourse to ascertain how well students can make inferences about when documents were written and about the beliefs or concepts that underlie each one
- Logbook or journal tasks that explore concepts or problems or situations over time or explores learning against pedagogy such as interactive simulations
- Event analysis
- Interpretation of video clips or visual materials
- Case study or studies examined over time as students move through courses and educational experiences
- Oral examination
- E Portfolio—collection of student work based on selected assignments in the curriculum
- Concept, knowledge or process maps (visual representation)
- Concept inventories, such as in physics and in chemistry
- Knowledge surveys
- Agreed upon embedded assignments or common assignments you will sample such as in a final examination
- Writing, to speaking, to visual presentation
- Observations of interactions, decision making, simulations
- Case study with analysis—use of parallel case studies over time

- Self-reflective writing—especially useful after students have received feedback or have engaged in a sub-task or task
- Externally or internally reviewed student projects
- Locally developed tests or other instruments
- Standardized exams
- Problem with solution and ask for other solutions
- Mining of data such as learning objects at Merlot: students make inferences about original work from a particular period of time, such as from literature, painting, letters and other historical documents
- Observation of a debate (particularly useful for a focus on ethical issues)
- Virtual simulations
- Milestone exams
- Complex problems that can be approached from many perspectives or disciplines
- Revisiting a problem over time to track learning
- Knowledge, decision, or procedural maps http://classes.aces.uiuc.edu/aces100/mind/c_m2.html:

Spider Concept Map



- **Situated Experiences along the Chronology of Learning**

  - Community-based projects (research) launched in the first year
  - Internships
  - Experiments
  - Research launched in the first year to solve a relevant problem
  - Research with faculty
  - Solo or team projects launched in the first year

    - Co-designed projects with a mentor or mentors (curricular-co-curricular projects, for example)

- **Chronological use of a case study at significant points in the GE curriculum to assess students' abilities to transfer and apply new knowledge, concepts, etc., to a complex, muddy problem**

- **Chronological Use of Complex Problems that Necessitate the Integration of Quantitative Literacy**
    - "Quantitative literacy, the ability to discriminate between good and bad data, the disposition to use quantitative information to think through complex problems—these are capacities that educators across fields should be helping students develop." From: Burke, Michael C. (October, 2007). "A Mathematician's Proposal." ***Carnegie Perspectives***. www.carnegiefoundation.org/perspectives/sub.asp?key=245&subkey)

- **E-Portfolios that Store Evidence of Integration over Time against the Background of the Curriculum and Co-curriculum. E-portfolios Should also Include Chronological Self-reflection on How One's Perspectives, Knowledge, Performance, etc., Changed over Time**

- **Smaller Projects over Time that Lead to a Final "Capstone Project**"

<u>Assessment via Technology</u>

- Team work across media (digital media and interfaces) and modes of communication

- Authorship of a simulation or a webpage

- Performance in virtual environments—virtual reality

- Data mining online

- Threaded discussions online

- Creation of wikis

- Gaming accompanied with one's analysis
    - "critical thinking," "probing," "telescoping" From: Holbert, Nathan. (February, 2008). "*Shooting Aliens: The Gamer's Guide to Thinking*." ***Educational Leadership.*** Vol. 65. No.5.)
- Podcasts
- Clickers to assess transfer of or new application of learning
- Online exercises
- Online journals
- interactive computer simulated tasks that provide data on patterns of actions, decisions, etc. (for example, eCollege claims it provides these kinds of data)

Indirect Methods of Assessment

* Surveys, questionnaires

* Interviews

* CCSSE or NSSE

* SALG—Student Assessment of Learning Gains –www.SALG.edu

* SGID—small group instructional design

* Institutional data (course-taking patterns, audit of syllabi)

Sample Assessment Report Questions

List of Learning Outcomes :

What process did you undertake to develop and achieve agreement among colleagues about your learning outcome statements?

How did you validate these outcomes internally and externally?

If you used specialized or professional standards, did you also complement those with institutional-specific learning outcomes?

What process will you undertake to periodically review and perhaps revise your learning outcome statements?

Performance Criteria

Describe the process you collectively underwent to articulate the attributes (knowledge, skills, behaviors) that demonstrate an outcome or set of outcomes or to determine that a norm-based instrument was valid for your program.

How did you assure reliability of your scoring?

Strategies for Teaching/Learning

How are courses and the curriculum or co-curriculum intentionally designed to contribute to students' learning of these agreed upon learning outcome statements?

Did your department develop a curricular or curricular-co-curricular map? Were there obstacles you faced in attempting to discern how well courses, the curriculum, or co-curriculum contribute to students' learning of these agreed upon learning outcome statements? If so, please describe how you addressed these obstacles?

Program-Level Assessment Method(s) and Timing

How did you identify the kinds of direct and indirect methods of assessment you chose to use to assess specific learning outcome statements?

How did you determine that your direct methods align with students' teaching and learning and course-based assessment methods?

Identify the timeline you followed and the strategy you used to summatively assess students' achievement of specific learning outcome statements (for example, required capstone project in a final course; embedded case study in a final exam?

Who was responsible for implementing your summative assessment method(s), collecting the results, scoring the results and preparing the analysis of results?

Expected Level of Achievement

Identify the level at which you expected students to perform either through norm-based or criteria-based interpretations.

Explain how you set this level of expectation (nationally established, locally established, professionally established by an organization).

Actual Level of Achievement

Describe how well students actually achieved in relation to your expected level(s) of achievement with specific focus on item analysis or analysis of criteria you used.

Analysis and Interpretation of Data

If you developed or used a scoring rubric, describe students' patterns of strength and weaknesses against your criteria

If you used a standardized instrument, describe students' patterns of strength and weakness using item or content analysis provided by the developer of the instrument

In both cases describe how your department members interpreted these results, drawing on other sources of data, such as institutional data or department data, such as course taking patterns.

Actions Taken

What specific changes have you made or will you make in pedagogy, curricular design or sequencing, instructional design, or educational practices to improve teaching and learning?

Timetable for Reassessment

Once these changes are implemented, identify when you intend to reassess students' performance to ascertain that these changes contribute to improving student learning.

If you have already reassessed, what did you learn about the efficacy of your changes?

Department/Program Template for Assessing Your Students' Learning
from Peggy Maki

Has your department/program:

- Collaboratively articulated department or program-level learning outcome statements?

- Mapped where and how students progressively learn these outcomes and identified points along the curriculum, as well as at the culmination of the program of study, when students build upon and demonstrate these collaboratively agreed upon outcomes?

- Discussed the design of the curriculum as reflected in a departmental curricular map, focusing on (1) pedagogies or educational practices that chronologically foster desired learning outcomes and on (2) how faculty intentionally build upon each others' courses and educational experiences to continue to foster students' learning

- Oriented and chronologically acculturated students to these outcomes

- Oriented new and adjunct faculty to these outcomes

- Integrated these outcomes into syllabi so that students continue to think about and reflect on their learning

- Created times along students' program of study to position them to assess their learning gains across their program of study, such as in focus groups or at the end of courses, and used these results for departmental discussions

- Collaboratively developed and distributed criteria and standards of judgment, scoring rubrics, to assess students' progress towards and achievement of your department-level outcomes and to position students to self- or peer assess

- Identified times to convene department members to analyze, interpret and use results of assessment to identify patterns of strength and weakness in student work that lead to discussion about and reflection on ways to improve student achievement through changes in pedagogy, curricular and instructional design, or other educational practices

- Identified times to implement collaboratively agreed upon changes to ascertain how well these changes improve student learning