

Activities In Engineering Education That Reflect Langford's Update of Bloom's Taxonomy of Cognitive Skills

Level (1) KNOWLEDGE (INFORMATION)

How do I know I have reached this level?

I can recall information about the *subject, topic, competency, or competency area*; I can *recall* the appropriate material at the appropriate time. I have been *exposed* to and have *received* the information about the subject; thus, I can respond to questions, perform relevant tasks, etc.

What do I do at this level?

I read material, listen to lectures, watch videos, take notes; I pass 'True/False', 'Yes/No', 'multiple choice', or 'fill in the blank' tests which demonstrate my *general knowledge* of the *subject*. I learn the vocabulary or terminology as well as the conventions or rules associated with the *subject*.

How will the teacher know I am at this level?

The teacher will provide *verbal* or *written* tests on the *subject* that can be answered by simply *recalling* the material I have learned about this subject.

What does the teacher do at this level?

The teacher directs, tells, shows, identifies, examines the subject or competency area *at this level*.

What are typical ways I can demonstrate my knowledge?

1. Answer 'True/False', 'Yes/No', 'fill in the blank', or 'multiple choice' questions correctly.
2. Define technical terms associated with the subject by stating their attributes, properties, or relations.
3. Recall the major facts about the subject.
4. Name the classes, sets, divisions, or arrangements that are fundamental to the subject.
5. List the criteria used to evaluate facts, data, principles, or ideas associated with the subject.
6. List the relevant principles and generalizations associated with the subject.
7. List the characteristic methods of approaching and presenting ideas associated with the subject (e.g., list the conventions or rules associated with the subject).
8. Describe the general problem solving method (i.e., the techniques and procedures) or the method(s) of inquiry commonly used in the subject area.

What are typical work products?

1. Answers to Knowledge level quizzes ('True/False', 'Yes/No', 'fill in the blank', or 'multiple choice').
2. Lists of definitions or relevant principles and generalizations associated with the subject.
3. Modifications of example problems presented in the textbook; for example, modest changes in numerical values or units; i.e., solutions to problems which were solved using 'pattern recognition'.

What are descriptive 'process' verbs?

define	label	listen	list	memorize	name
read	recall	record	relate	repeat	view

Level (2) COMPREHENSION (UNDERSTANDING)

How do I know I have reached this level?

I comprehend or understand the *subject, topic, competency, or competency area*; I use ideas associated with the subject without relating them to other ideas or subjects. I may not yet completely understand the subject. When others are discussing this subject, I can follow and understand the discussion. This level requires Knowledge.

What do I do at this level?

I successfully solve textbook problems using appropriate techniques and procedures based on (1) where the problem is located in the book or (2) the problem statement. I translate ideas into my own words (translation from one level of abstraction to another). I translate graphical or symbolic information (e.g., tables, diagrams, graphs, mathematical formulas, etc.) into verbal forms, and vice versa. I interpret or summarize communications (oral/written/graphical). I can use the problem solution to determine effects, trends, implications, corollaries, etc.

How will the teacher know I am at this level?

The teacher will ask questions that can be answered by restating or reorganizing material in a literal manner; i.e., by clearly stating facts or the principle meaning of the material in your own words. The teacher will also give tests based on the textbook problems that were (1) assigned as homework or (2) used as examples in the textbook or in class.

What does the teacher do at this level?

The teacher demonstrates, solves problems, listens, questions, compares, contrasts, and examines the information and your knowledge of the subject.

What are typical ways I can demonstrate, on my own, my comprehension and understanding?

1. Read textbook problems, understand what is required, and successfully solve the problems.
2. Clearly document the process used to solve the problem.
3. Clearly describe the solution to the problem.
4. Draw conclusions based on the solution to the problem.

5. Compare/contrast two different textbook problems (i.e., what elements are the same? what elements are different?).
6. Restate an idea, theory, or principle in your own words.

What are typical work products?

1. Answers to Comprehension level quizzes and exams ('multiple choice' or textbook problems).
2. Solutions to textbook problems which include (a) a summary of the learning objectives associated with the problem, (b) the problem statement in the form of a clearly labeled sketch, specifications, and what is required, (c) a description of the general solution method (techniques and procedures) used to solve the problem, and (d) a discussion of the solution.

What are descriptive 'process' verbs?

describe	discuss	explain	express	identify	locate
recognize	report	restate	review	solve	tell

Level (3) APPLICATION (INDEPENDENT PROBLEM SOLVING)

How do I know I have reached this level?

I can recognize the need to use an idea, concept, principle, theory, or general solution methods (techniques and procedures) without being told and without any specific or immediate context or cues. For example, I do not need to locate a similar example in a textbook, nor do I need to know that an assignment is for a particular course in order to recognize the need to use a particular idea, etc. I know and comprehend these ideas, concepts, principles, theories, or general solution methods (techniques and procedures) and I can apply them to new situations. I also have the ability to recognize when a certain task or project is beyond my current competency. This level requires Knowledge and Comprehension.

What do I do at this level?

I apply ideas, concepts, principles, theories, or general solution methods (techniques and procedures) that I learned at the Knowledge and Comprehension level to new situations. I solve problems in which the solution method is not immediately evident or obvious. I solve these problems independently and make use of other techniques and procedures as well. This requires not only knowing and comprehending these ideas, concepts, principles, theories, and general solution methods (techniques and procedures) but deep thinking about their usefulness and how they can be used to solve new problems that I identify or define.

How will the teacher know I am at this level?

The teacher will review my work products and confirm that I am solving problems independently, in new situations, and without prompting by the teacher. The teacher will be able to pose general questions such as "*How much protection from the sun is enough?*" and I will know how to answer the question by defining and solving a problem.

What are the typical ways I can demonstrate, on my own, my Application of Knowledge and Comprehension?

1. Solve problems which require that I recognize and apply the appropriate ideas, concepts, principles, theories, general solution methods (techniques and procedures), etc. without being told and without any specific or immediate context or cues.
2. Apply the laws of mathematics, chemistry, and physics, as well as engineering, business or design concepts, etc. to practical problems or situations.
3. Solve problems associated with *design/build* projects.

What are typical work products?

Application level work products are very similar to Comprehension level work products; however, documentation will be included which demonstrates that you recognized the need to use ideas, concepts, principles, theories, general solution methods (techniques and procedures), etc. in a new situation.

What are descriptive process verbs?

apply	demonstrate	employ	illustrate	interpret
operate	practice	recognize	solve	use

Level (4) ANALYSIS (LOGICAL ORDER, COMPONENTS)

How do I know I have reached this level?

I can explain *why*. I can methodically examine ideas, concepts, principles, theories, general solution methods (techniques and procedures), reports, etc. and separate these into their component parts or basic elements. I can use the results of this examination to clarify the organization of the whole or to gain a global view. This level requires Knowledge and Comprehension Levels of Learning; Application is not required.

What do I do at this level?

I demonstrate that I can analyze results by breaking ideas, concepts, principles, theories, general solution methods (techniques and procedures), reports, etc. into their component parts. I explain the logical interconnections of the parts. I can also develop detailed cause and effect sequences.

What does the teacher do at this level?

The teacher probes, guides, observes, and acts as a resource or facilitator.

What are typical questions I can ask myself that will demonstrate my Analysis Level of Learning?

1. What are the causal relationships between the parts and how the whole functions?
2. Can I explain, from the parts, why the whole does or does not work?
3. Are the conclusions supported by sound reasoning?
4. Does the evidence provided support the hypothesis or the conclusion?

5. Are the conclusions supported by facts, opinions, or an analysis of the results?
6. What are the unstated assumptions, if any?

What are typical work products?

1. Answers to Analysis level exams (problems, multiple choice, essays).
2. Analysis level work products are very similar to Comprehension level work products; however, documentation will include a more extensive discussion of the work. The content, amount, and depth of the presentation is what distinguishes Analysis level work products from Comprehension level work products; e.g., see items 1 through 6 above.

What are descriptive process verbs?

analyze	appraise	break apart	break down	calculate
compare	contrast	debate	diagram	differentiate
examine	experiment	explain	inspect	inventory
question	relate	solve		

Level (5) SYNTHESIS (CREATE)

How do I know I have reached this level?

I have the ability to assemble parts and elements into a unified organization or whole that requires original or creative thinking. I recognize new problems and develop new tools to solve them. I create my own plans, models, hypotheses, etc. for constructing solutions to problems. This Level of Learning requires Knowledge, Comprehension, Application and Analysis Levels of Learning.

What do I do at this level?

I generate ideas and use them to create a physical object, a process, a design method, a written or oral communication, or even a set of abstract relations (e.g., mathematical models). I produce written or oral reports that have the desired effect (e.g., information acquisition, acceptance of a point of view, continued support, etc.) on the reader or listener. I generate project plans. I propose designs. I formulate hypotheses based on the analysis of relevant or pertinent factors. I am able to generalize from a set of axioms or principles.

How will the teacher know I am at this level?

I demonstrate that I can combine ideas into a statement, a plan, a product, etc. that was previously unknown to me; e.g., I develop a program that includes the best parts of each of these ideas.

What does the teacher do as this level?

The teacher reflects, extends, analyzes, and evaluates.

What are the typical questions I can ask myself that will demonstrate my Synthesis Level of Learning?

1. Can I create a project plan?
2. Can I develop a model?
3. Can I propose a design?

What are typical work products?

1. Answers to Synthesis level exams (problems, multiple choice, essays).
2. Synthesis level work products are very similar to Comprehension level work products; however, documentation will include a more extensive discussion of the work. The content, amount, and depth of the presentation is what distinguishes Synthesis level work products from Comprehension level work products; e.g., see items 1 through 3 above.

What are descriptive process verbs?

arrange	assemble	collect	compose	construct
create	design	formulate	manage	organize
plan	prepare	propose	set up	write

Level (6) EVALUATION (APPRECIATION)

How do I know I have reached this level?

I have the ability to judge and appreciate the value of ideas, concepts, principles, theories, or general solution methods (techniques and procedures) using appropriate criteria. This level requires Knowledge, Comprehension, Application, Analysis, and Synthesis Levels of Learning.

What do I do at this level?

I make value judgments based on certain criteria such as usefulness and effectiveness. Based on information gained through application, analysis, and synthesis, I can rationally select a process, a method, a model, a design, etc. from among a set of possible processes, methods, models, designs, etc. I evaluate competing plans of action before actually starting the work. I evaluate work products based on internal standards of consistency, logical accuracy, and the absence of internal flaws; e.g., I can certify that the feasibility of a design has been demonstrated in a report. I evaluate work products based on external standards of efficiency, cost, or utility to meet particular goals or objectives; e.g., I can certify that the quality of the design has been demonstrated in a report.

How will the teacher know I am at this level?

I demonstrate that I can select, judge, or appreciate a process, a method, a model, a design, etc. using appropriate criteria or standards.

What does the teacher do at this level?

The teacher clarifies, accepts, harmonizes, aligns, and guides.

What are typical statements and questions I can answer to that will demonstrate or show my appreciation/evaluation?

1. I can evaluate an idea in terms of ...
2. For what reasons do I favor...?
3. Which policy do I think would result in the greatest good for the greatest number?
4. Which of these models or modeling approaches is best for my current needs?
5. How does this report demonstrate that the design is feasible?
6. How does this report demonstrate the quality of the design?

What are typical work products?

1. Answers to Evaluation level exams (problems, multiple choice, essays).
2. Evaluation level work products are very similar to Comprehension level work products; however, documentation will include a more extensive discussion of the work. The content, amount, and depth of the presentation is what distinguishes Evaluation level work products from Comprehension level work products; e.g., see items 1 through 6 above.

What are descriptive process verbs?

appraise	assess	choose	compare	estimate (quality)
evaluate	judge	predict (quality)	rate value	select

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