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The Evaluation of Thinking Skills based on Taxonomy of Anderson and Krathwohl

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Abstract

Learning activities should involve explicit thinking skills. It is more convenient to categorize thinking skills based on the existing frameworks. The framework that is still considered very useful and popular among educators is Taxonomy Bloom (1956). Bloom's Taxonomy of cognitive domain is categorized into six type of thinking skills (Meyer, 1988; Som and Mohd Dahalan, 1998; Widad and Kandar, 2006). According to Tee *et al.* (2009), lower order thinking skills are the level of knowledge, understanding and application, while the level of higher order thinking skills are analysis, synthesis and evaluation. However, a revised on Taxonomy Bloom had been done by Bloom's students, Anderson and Krathwohl in the year of 2001. There are some significant changes based on the revised taxonomy. This article will discuss about the Piaget's cognitive theory and the differences between cognitive and meta-cognitive. In addition, Bloom's Taxonomy (1956) and Taxonomy of Anderson and Krathwohl (2001) will also be discussed. Besides that, this article will also address the action verbs widely used in each level of thinking skills and thinking skills evaluation tools such as objective tests, essay tests, and rubric.

Keywords: Thinking Skills, Bloom's Taxonomy, Taxonomy of Anderson and Krathwohl, Thinking Skills Evaluation Tools

1. Cognitive theory

According to Rajendran (2008), Piaget's theory is one of the most well-known theories of cognitive development. Based on this theory, children develop their thinking according to successive, discrete stadium. In other words, this theory explains how people think as they progress from infancy through childhood to adolescence and ultimately into adulthood. Besides that, Piaget emphasizes thinking in a certain stadium is qualitatively different from the thinking in the past or the next stadium. Piaget also viewed children as active learners who behave like 'little scientists' who develop their own 'theories' about how the world works and set out to confirm these hunches (Widad and Kandar, 2006). Piaget's main concern was to discover how people acquire knowledge, which is often called the 'epistemological question'.

Piaget identifies that throughout the lifespan, people go through sequence of four developmental stages of thinking (Rajendran, 2008; Widad and Kandar, 2006; Mohd Azhar, 2003). They are as the followings:

Sensory-motor: (birth to 2 years old) - Infants acquire knowledge based on their sensory experiences, such as sight, hearing, touch, taste, and smell. It involves adapting to reality through sensing and movement. A child does not know that physical objects remain in existence even when it is out of sight (object permanence) in this stage.
Preoperational period: (2 to 7 years old) - Preschoolers moves to the stage of acquiring knowledge of the world through their perceptions of their own experiences in the real world. It involves processes related to conceptualization prior to using logic. In other words, the children haven't able to conceptualize abstractly as they need concrete physical situations.
Concrete Operations period: (7 to 11 years old) - as physical experience accumulates, children begin to conceptualize, creating logical structures that explain their physical experiences. By the way, abstract problem solving is possible in this stage. They begin to apply the rules of logic to understand how the world works and this involves using applied reasoning.

Formal Operations period: (11 to 15 years and up) – The children's cognitive structures are like those of an adult. They are able to do conceptual reasoning. Adolescents and adults progress to the stage where they can apply logic to hypothetical as well as to real situations and this involves using systematic reasoning.

As a conclusion, Piaget believed that people are constantly trying to make sense of the world by comparing their internal understanding of how the world works with external environment (Widad and Kandar, 2006). Learning occurs when people periodically alter their internal understanding of the world as they encounter external evidence that conflicts with their previous understanding. Given Piaget's theory, therefore, it is important to provide students with experiences that will help them develop a more accurate understanding of how the things work.

2. Cognitive and metacognitive

Rajendran (2008) explains that metacognition is basically thinking about thinking. It refers to higher order thinking that involves active control over the thinking process engaged in learning. On the other hand, Anderson et al. (2001) define metacognitive knowledge as knowledge about cognition in general as well as awareness of and knowledge about one's own cognition. It includes knowledge of general strategies that may be used for different tasks, the conditions under which these strategies may be used the extent to which the strategies are effective, and self-knowledge. In addition, Guskey and Marzano (2001) stressed that metacognitive system has been described by researchers and theorists as responsible for monitoring, evaluating and regulating the functioning of all other types of thought.

Learning process engages learners with all sorts of activities such as listening, reading, writing or drawing. All activities should clearly involve thinking skills that are explicit. In this way it is possible for metacognitive processes to be introduced or used.

Table 1 shows some examples of ways in which activities might account for cognitive and metacognitive needs based on Taxonomy of Anderson and Krathwohl (2001).

Table 1. Cognitive Vs metacognitive

	Cognitive	**Metacognitive**	
Question?	What to do?	How to do it?	
Ability	Can undertake a task	Know how to:	
		(i)	Approach it
		(ii)	Using different ways on doing it
		(iii)	Having methods available
		(iv)	Understanding a range of possible processes and strategies
Remember	Can read a passage to find specific information	Knows a range of ways of finding which texts might contain specific information	
Understand	Can answer questions based on a document that has been read	Knows how to detect key features of documents and at the same time how to identify things that is not known	
Apply	Can use information or techniques into other contexts or situations	Knows which techniques or strategies to be used to recall specific information or skills in a range of different situations	
Analyze	Can ask questions about information, differentiating, organizing and attributing answers with existing knowledge or understanding	Knows a range of techniques or strategies that can be used when questions are asked to analyze information or data by differentiating, organizing and attributing	
Evaluate	Can make decisions about information or ideas using a specific range of criteria	Knows the techniques or strategies that enable evaluation to be undertaken reasonably and reliably	
Create	Can bring together information from a range of sources and create a coherent outcome	Knows a range of techniques or strategies that will enable coherent outcomes to be created when a range of sources of information and details are being used	

3. Bloom's taxonomy (1956)

Benjamin Bloom headed a group of educational psychologists and developed a classification of levels of intellectual behavior important in learning in the year of 1956. Bloom found that over 95 % of the test questions students encounter only require them to think at the lowest possible level.

According to Widad and Kandar (2006), bloom identified six levels within the cognitive domain, from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order which is classified as evaluation.

Based on Bloom (1956), the taxonomy begins by defining **knowledge** as the remembering of previously learned material. Knowledge is the lowest level of learning outcomes in the cognitive domain. Knowledge is followed by **comprehension**, the ability to grasp the meaning of material and goes just beyond the knowledge level. Furthermore, comprehension is the lowest level of understanding. On the other hand, **Application** is the next area in the hierarchy and refers to the ability to use learned material in new and concrete principles and theories. Thus, application requires a higher level of understanding than comprehension.

Moreover, **analysis** is the next area of the taxonomy; the learning outcomes require an understanding of both the content and the structural form of material. **Synthesis** refers to the ability to put parts together to form a new whole. Learning outcomes at this level stress creative behaviors with a major emphasis on the formulation of new patterns or structures. Finally, the last level of the taxonomy is **evaluation**. Evaluation is concerned with the ability to judge the value of material for a given purpose. The judgments are to be based on definite criteria. Learning outcomes in this area are the highest in the cognitive hierarchy because they incorporate or contain elements of knowledge, comprehension, application, analysis, and synthesis.

Table 2 summarizes the definition for the six cognitive processes.

Table 2. Definitions of the six cognitive processes

Knowledge	The ability to remember previous learned material. It represents the lowest level of learning outcomes in the cognitive domain.
Comprehension	The ability to grasp the meaning of material and goes just beyond the knowledge level. Comprehension is the lowest level of understanding.
Application	The ability to use learned material in new and concrete principles and theories. Application requires a higher level of understanding than comprehension.
Analysis	An understanding of both the content and the structural form of material.
Synthesis	The ability to put parts together to form a new whole. Learning outcomes at this level stress creative behaviors with a major emphasis on the formulation of new patterns or structures.
Evaluation	The ability to judge the value of material for a given purpose. The judgments are to be based on definite criteria. It incorporates or contains elements of knowledge, comprehension, application, analysis, and synthesis.

Table 3 presents some of the common verbs used in each level of cognitive process.

Table 3. Common verbs used in each level of cognitive process

Knowledge	arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state
Comprehension	classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate
Application	apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write
Analysis	analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test
Synthesis	arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write
Evaluation	appraise, argue, assess, attach, choose compare, defend, estimate, judge, predict, rate, core, select, support, value, evaluate

4. Taxonomy of Anderson and Krathwohl (2001)

Bloom's taxonomy was revised by his former students, Lorin Anderson, working with one of his partners in the original work on cognition, David Krathwohl. The group redefining Bloom's original concepts, worked from 1995-2000. The group was assembled by Anderson and Krathwohl and included people with expertise in the areas of cognitive psychology, curriculum and instruction, and educational testing, measurement, and assessment.

The major differences in the updated version is in the more useful and comprehensive additions of how the taxonomy intersects and acts upon different types and levels of knowledge -- factual, conceptual, procedural and metacognitive.

4.1 The Knowledge Dimension

Table 4. The knowledge dimension

MAJOR TYPES AND SUBTYPES		EXAMPLES
A.	**FACTUAL KNOWLEDGE** – The basic elements students must know to be acquainted with a discipline or solve problems in it.	
AA.	Knowledge of terminology	Technical vocabulary, musical symbols
AB.	Knowledge of specific details and elements	Major natural resources, reliable sources of information
B.	**CONCEPTUAL KNOWLEDGE** – The Interrelationship among the basic elements within a larger structure that enable them to function together.	
BA.	Knowledge of classifications and categories	Periods of geological time, forms of business ownership
BB.	Knowledge of principles and generalizations	Pythagorean theorem, law of supply and demand
BC.	Knowledge of theories, models and structures	Theory of evolution, structure of Congress
C.	**PROCEDURAL KNOWLEDGE** – How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	
CA.	Knowledge of subject-specific skills and algorithms	Skills used in painting with watercolors, whole-number division algorithms
CB.	Knowledge of subject-specific techniques and methods	Interviewing techniques, scientific method
CC.	Knowledge of criteria for determining when to use appropriate procedure	Criteria used to determine when to apply a procedure involving Newton's second law, criteria used to judge the feasibility of using a particular method to estimate business costs
D.	**METACOGNITIVE KNOWLEDGE** – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition	
DA.	Strategic knowledge	Knowledge of outlining as a means of capturing the structure of a unit of subject matter in a textbook, knowledge of the use of heuristics
DB.	Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge	Knowledge of types of tests particular teachers administers, knowledge of the cognitive demands of different tasks
DC.	Self-knowledge	Knowledge that critiquing essays is a personal strength, whereas writing essays is a personal weakness; awareness of one's own knowledge level

Note: Adapted from Anderson *et al.*, 2001, p. 46.

One of the things that differentiate the new model from that of the 1956 original is that it lays out components nicely so they can be considered and used. And while the levels of knowledge were indicated in the original work: factual, conceptual, and procedural (Table 4) -- these were never fully understood or used by teachers because most of what educators were given in training consisted of a simple chart with the listing of levels and related accompanying verbs.

The full breadth of Handbook I and its recommendations on types of knowledge were rarely discussed in any instructive way. Nor were teachers in training generally aware of any of the criticisms of the original model. The updated version has added "metacognitive" to the array of knowledge types. Here are the intersections as the processes impact the levels of knowledge. Using a simple cross impact grid or table like the one below, one can match easily activities and objectives to the types of knowledge and to the cognitive processes as well (Table 5).

Table 5. Table of taxonomy

	The Cognitive Process Dimension					
The Knowledge Dimensions	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual						
B. Conceptual						
C. Procedural						
D. Metacognitive						

Knowledge dimensions defined:

Factual Knowledge is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a discipline or solve a problem in it.
Conceptual Knowledge is knowledge of classifications, principles, generalizations, theories, models, or structures pertinent to a particular disciplinary area.
Procedural Knowledge refers to information or knowledge that helps students to do something specific to a discipline, subject, and area of study. It also refers to methods of inquiry, very specific or finite skills, algorithms, techniques, and particular methodologies.
Metacognitive Knowledge is the awareness of one's own cognition and particular cognitive processes. It is strategic or reflective knowledge about how to go about solving problems, cognitive tasks, to include contextual and conditional knowledge and knowledge of self.

4.2 Visual Comparison Of The Two Taxonomies

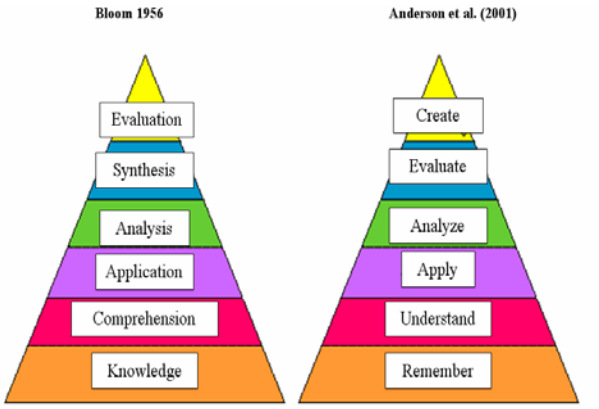

Fig. 1. Visual comparison of the two taxonomies.

Table 6. The cognitive process dimension

Categories & cognitive processes		**Alternative names**	**Definitions and examples**
1.	**Remember** – Retrieve relevant knowledge from long-term memory		
1.1	**Recognizing**	Identifying	Locating knowledge in long-term memory that is consistent with presented material (e.g., Recognize the dates of important events in U. S. history.)
1.2	**Recalling**	Retrieving	Retrieving relevant knowledge from long-term memory (e.g., Recall the dates of important events in U. S. history.)
2.	**Understand** – Construct meaning from instructional messages, including oral, written, and graphic communication.		
2.1	**Interpreting**	Clarifying, paraphrasing, representing, translating	Changing from one form of representation (e.g., numerical) to another (e.g., verbal) (e.g., Paraphrase important speeches and documents.)
2.2	**Exemplifying**	Illustrating, instantiating	Finding a specific example of illustration of a concept or principle (e.g., Give examples of various artistic painting styles).
2.3	**Classifying**	Categorizing, subsuming	Determining that something belongs to a category (e.g., concept of principle) (e.g., Classify observed or described cases of mental disorders).
2.4	**Summarizing**	Abstracting, generalizing	Abstracting a general theme or major point(s) (e.g., Write a short summary of the events portrayed on a videotape).
2.5	**Inferring**	Concluding, extrapolating, interpolating, predicting	Drawing a logical conclusion from presented information (e.g., In learning a foreign language, infer grammatical principles from examples).

2.6	**Comparing**	Contrasting, mapping, matching	Detecting correspondences between two ideas, objects, and the like (e.g., Compare historical events to contemporary situations).
2.7	**Explaining**	Constructing models	Constructing a cause-and-effect model of a system (e.g., Explain the causes of important 18th-century events in France).
3.	**Apply** – Carry out or use a procedure in a given situation		
3.1	**Executing**	Carrying out	Applying a procedure to a familiar task (e.g., Divide one whole number by another whole number, both with multiple digits).
3.2	**Implementing**	Using	Applying a procedure to an unfamiliar task (e.g., Use Newton's Second Law in situations in which it is appropriate.)
4.	**Analyze** – Break into its constituent parts and determine how the parts relate to one another and to an overall structure and purpose.		
4.1	**Differentiating**	Discriminating, distinguishing, focusing, selecting	Distinguishing relevant from irrelevant parts or important from unimportant parts of presented material (e.g., Distinguish between relevant and irrelevant numbers in a mathematical word problem).
4.2	**Organizing**	Finding coherence, integrating, outlining, parsing, structuring	Determining how elements fit or function within a structure (e.g., Structure evidence in a historical description into evidence for and against a particular historical explanation).
4.3	**Attributing**	Deconstructing	Determine a point of view, bias, values, or intent underlying presented material (e.g., Determine the point of view of the author of an essay in terms of his or her political perspective).
5.	**Evaluate** – Make judgments based on criteria and standards		
5.1	**Checking**	Coordinating, detecting, monitoring, testing	Detecting inconsistencies or fallacies within a process or product; determining whether a process or product has internal consistency; detecting the effectiveness of a procedure as it is being implemented (e.g., Determine if a scientist's conclusions follow from observed data).
5.2	**Critiquing**	Judging	Detecting inconsistencies between a product and external criteria, determining whether a product has external consistency; detecting the appropriateness of a procedure for a give problem (e.g., Judge which of two methods is the best way to solve a given problem.)
6.	**Create** – Put elements together to form a coherent or functional whole, reorganize elements into new pattern or structure.		
6.1	**Generating**	Hypothesizing	Coming up with alternative hypothesis based on criteria (e.g., Generate hypothesis to account for an observed phenomenon).
6.2	**Planning**	Designing	Devising a procedure for accomplishing some task (e.g., Plan a research paper on a given historical topic).
6.3	**Producing**	Constructing	Inventing a product (e.g., Build habitats for a specific purpose).

Note: Adapted from Anderson et al., 2001, p. 67-68.

4.3 Changes from the Original Framework

Four changes in emphasis

1. The revision's primary focus in on the taxonomy in use.
2. The revision is aimed at a broader audience, emphasizing teachers.
3. Sample assessment tasks are included primarily to convey meaning.

4. The revision emphasizes the subcategories.

Four changes in terminology (Fig. 1)

5. Major category titles were made consistency with how objective are framed.
6. The knowledge subcategories were renamed and reorganized.
7. Subcategorized of the cognitive process categories were replaced by verbs.
8. Comprehension and synthesis were re-titled.

Four changes in structure

9. The noun and verbs components of objectives became separated dimensions.
10. The two dimensions are the basis for our analytical tool, the taxonomy table.
11. The process categories do not form a cumulative hierarchy.
12. The order of synthesis/create and evaluation/evaluate was interchanged.

5. THE ACTION VERBS WIDELY USED

These are the skills that every educator needs to develop in his or her teaching every day. Students should be exposed and taught about these verbs in schools to help them learn and achieve better grades.

5.1 Remember

The skills demonstrated at this level are those of:

(i) Observation and recall of information
(ii) Knowledge of dates, events, places
(iii) Knowledge of major ideas
(iv) Mastery of subject matter

Verbs:

List	Retrieve	Tell	Describe	Tabulate
Show	Label	Collect	Examine	What
Quote	Name	State	Recognize	When
Match	Recall	Define	Understand	
Who	Identify	Where	Remember	

These are some great ideas for activities that will develop the "remember" level of thinking. Here are some of the activities:

(i) List main points of the topic.
(ii) Match the characteristics with the pictures.
(iii) Identify the main characteristics.
(iv) Recall the important details by referring to the given pictures.
(v) Match the main statements with the supporting details.

5.2 Understand

The skills demonstrated at this level are:

(i) Interpretation of facts, compare, contrast
(ii) Order, group, and infer causes
(iii) Understanding information
(iv) Grasping meaning

Verbs:

Explain	Discuss	Elaborate	Simplify
Interpret	Summarize	Describe	Match
Outline	Restate	Report	Clarify
Classify	Infer	Compare	Illustrate
Paraphrase	Represent	Translate	Abstract
Instantiate	Categorize	Subsume	Interpolate
Generalize	Conclude	Extrapolate	
Predict	Contrast	Map	
Construct models	Give example	Extend	

These are some great ideas for activities that will develop the "understand" level of thinking. Here are some of the activities:

(i) Interpret pictures of tools from the given passage.
(ii) Explain selected ideas or parts from the text in own words.
(iii) Draw a picture showing what happened before and after from a given topic.
(iv) Write a sentence explaining what happened before and after from a given text.
(v) Construct a pictorial time line which summarizes what happens in the procedures from a passage.
(vi) Explain opinion at the beginning, middle and end of the text.

5.3 Apply

The skills demonstrated at this level are:

(i) Use information
(ii) Use methods, concepts, theories in new situations
(iii) Solve problems using required skills or knowledge

Verbs:

Apply	Demonstrate	Calculate	Complete
Illustrate	Show	Solve	Examine
Modify	Relate	Change	Classify
Act	Use	Choose	Run
Execute	Implement	Carry out	

These are some great ideas for activities that will develop the "apply" level of thinking. Here are some of the activities:

(i) Classify the characters as human, animal, or thing.
(ii) Transfer a main character to a new setting.
(iii) Act based on the given script.

(iv) Select a main point from the text and explain why you choose it.
(v) Think of a new method based on the text and explain what you would have handled it differently.
(vi) Give real examples based on the passage.

5.4 Analyze

The skills demonstrated at this level are:
(i) Seeing patterns
(ii) Organization of part
(iii) Recognition of hidden meanings
(iv) Identification of components

Verbs:

Classify	Sort	Arrange	Infer
Separate	Connect	Divide	Debate
Gather	Categorize	Compare	Attribute
Features	Analyze	Organize	Find coherence
Distinguish	Discriminate	Focus	
Integrate	Outline	Parse	
Deconstruct	Select	Structure	

These are some great ideas for activities that will develop this "analyze" level of thinking. Here are some of the activities:
(i) Identify general characteristics (main or implied) from the given text.
(ii) Distinguish what could happen from what couldn't happen in the passage in real situation.
(iii) Select parts of the text based on the chosen characteristics.
(iv) Differentiate fact from opinion.
(v) Compare and/or contrast two of the main points.
(vi) Select an action from the passage that was exactly the same as something other would have done in real life.

5.5 Evaluate

The skills demonstrated at this level are:
(i) Assess value of theories
(ii) Make choices based on reasoned arguments
(iii) Verify value of evidence
(iv) Recognize subjectivity
(v) Compare and discriminate between ideas

Verbs:

Assess	Grade	Summarize	Judge
Decide	Test	Convince	Support
Appraise	Measure	Select	Conclude
Comment	Conclude	Infer	Generalize
Criticize	Coordinate	Detect	Monitor
Consider	Recommend	Verify	Check

These are some great ideas for activities that will develop this "evaluate" level of thinking. Here are some of the activities:
(i) Decide which sentence is the most important point from the text and explain why.
(ii) Judge the validity of the main points.
(iii) Decide if the incident from the text really could have happened and justify why.
(iv) Consider how this skill can help one in the real situation.
(v) Appraise the value of the incident from the text.
(vi) Compare this incident with another one.
(vii) Write a recommendation as to why the book should be read by others or not.

5.6 Create

The skills demonstrated at this level are:
(i) Generalize from given facts
(ii) Relate knowledge from several areas
(iii) Predict, draw conclusions
(iv) Use old ideas to create new ones

Verbs:

Prepare	Rearrange	Generalize	Construct
Innovate	Design	Predict	Integrate
Modify	Generate idea	Plan	Analogy
Compose	Invent	Form	Substitute
What if	Synthesize	Produce	
Rewrite	Conceptualize	Devise	
Combine	Hypothesize	Formulate	

These are some great ideas for activities that will develop this "create" level of thinking. Here are some of the activities:
(i) Create a story from just the title before the passage is read. Use this as a pre-reading exercise.
(ii) Rewrite several new titles for the text.
(iii) Advertise the story on a poster to make people want to read it.
(iv) Restructure the main points from the text.
(v) Imagine that you are involved with the incident from the passage.
(vi) Create an original character and weave him/her into the existing story.
(vii) Write a lyrics or music to a song based on the text.

6. CONCLUSION

Educators and students should be alerted and exposed to the new taxonomy by Anderson and Krathwohl (2001). By referring to the verbs in each categories and cognitive processes (Table 6), educators are able to set up monthly test or final examination based on the table of specification more conveniently. With this knowledge, students could also assess themselves by doing practices based on the given verbs. Moreover, students can set up their own assessment questions by referring to the text book and especially the verbs widely used in each categories and cognitive processes.

On the other hand, educators could also plan interesting activities based on the taxonomy table and at the same time assessing the thinking level among the students in the classroom.

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