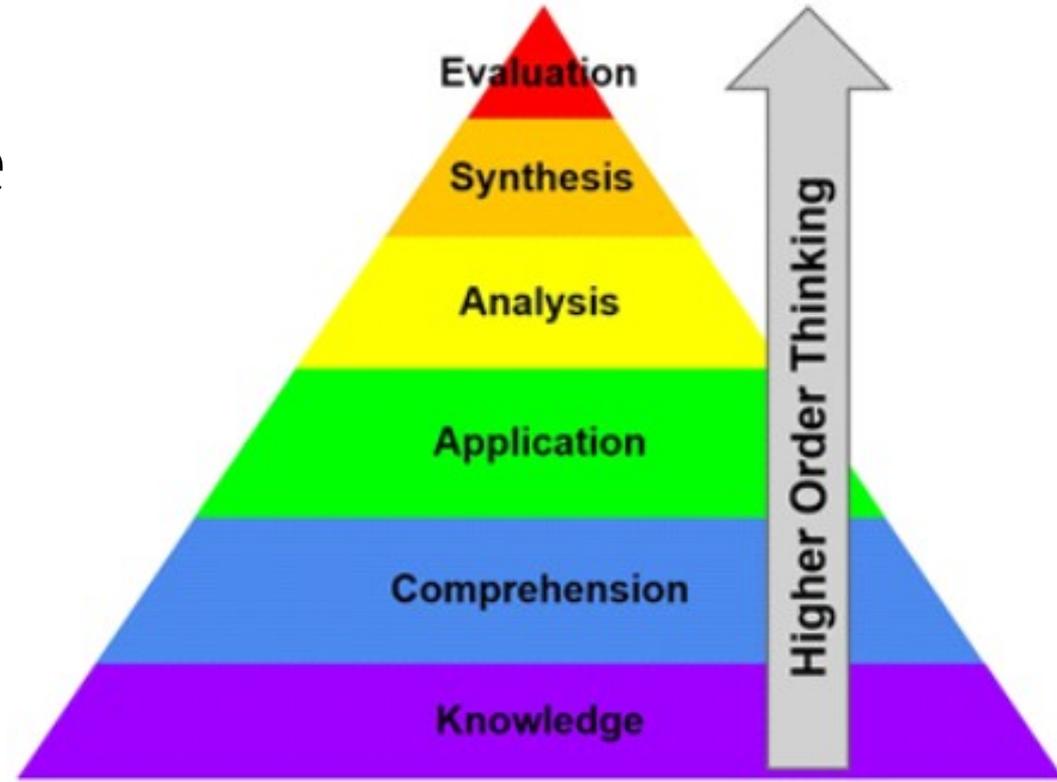


Critical Thinking

“The careful, deliberate determination of whether one should accept, reject, or suspend judgment about a claim and the degree of confidence with which one accepts or rejects it.”

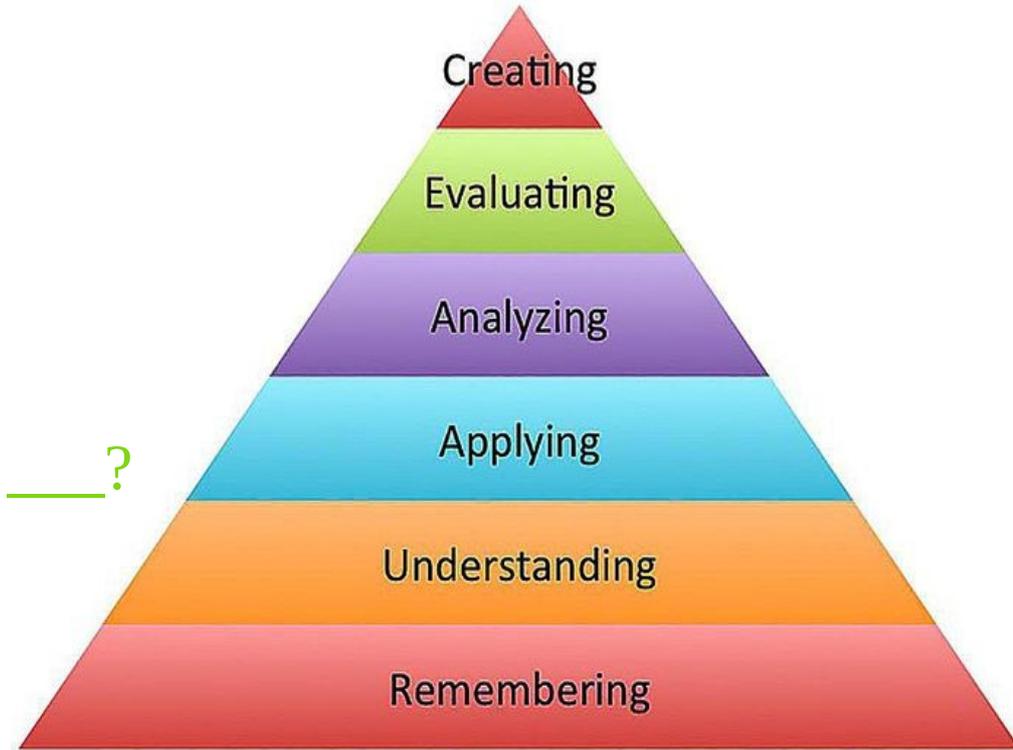
(Critical Thinking. B. Moore and R. Parker, 2007)

What are examples of different levels of higher order thinking?



Bloom's Taxonomy
Cognitive Domain

New Version of Bloom's Taxonomy



- **Analyzing:**

- How can you sort the parts ____?
- What can you infer ____?
- What ideas validate ____?

- **Evaluating:**

- What criteria would you use to assess ____?
- What data were used to evaluate ____?
- How could you verify ____?

- **Creating:**

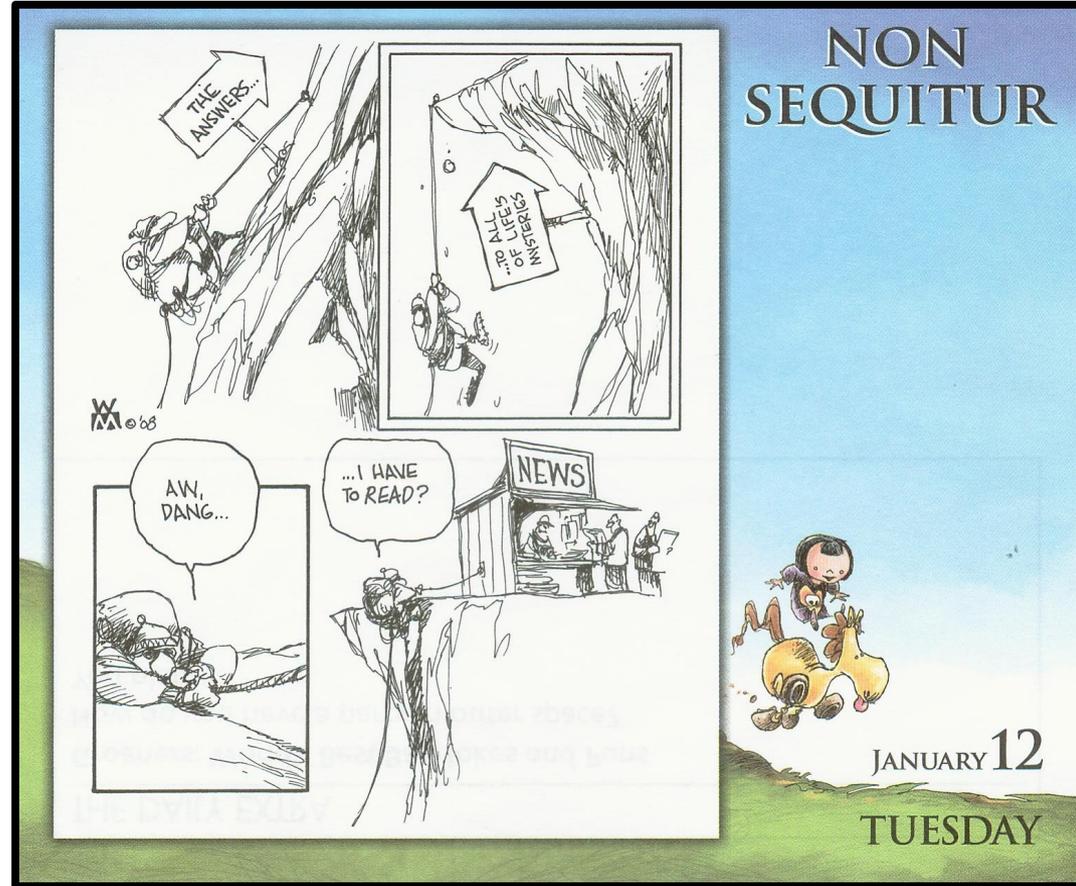
- What alternative would you suggest for ____?
- What changes would you make to revise ____?
- How would you generate a plan to ____?

What can you create
working at a University?

Examples of using Critical Thinking

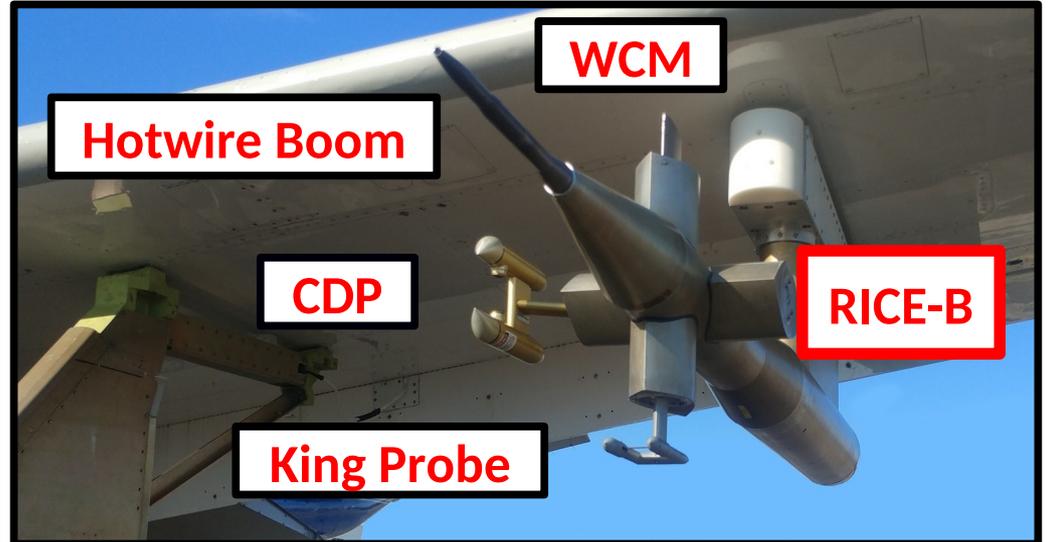
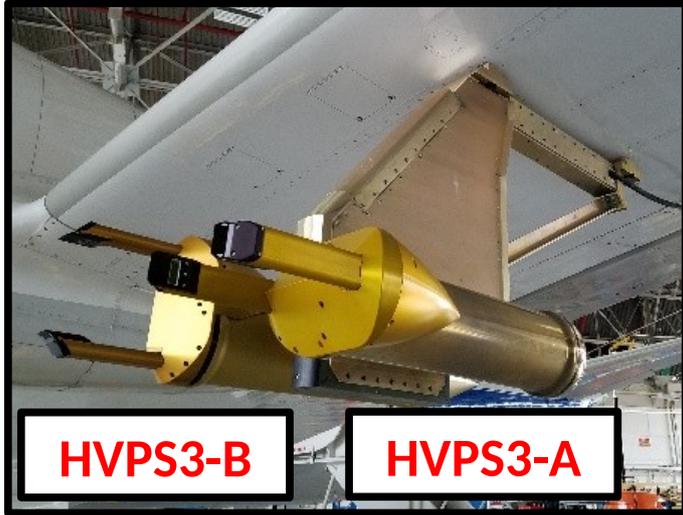
- To Approach Questions to Find an Answer
- To Solving Problems
- To Taking Action

Requires active thinking, the use of reason, and an open mind.



What is an example of how you used critical thinking?

How Does Critical Thinking Apply to Research?



Application of Critical Thinking

Critical thinking should be applied to:

- Expressing your own thoughts, beliefs, and opinions.
- Reading or listening to the thoughts, beliefs, opinions of others.



How can you apply critical thinking to class lectures?

Elements of Reasoning (Thinking)

- Reasoning has a purpose.
- Reasoning is figure something out.
- Reasoning is based on assumptions.
- Reasoning is from a point of view.
- Reasoning is based on information.
- Reasoning is expressed through concepts and theories.
- Reasoning contains interpretation of data and observations.
- Reasoning has implications and consequences.

Periodic Table of the Elements

The periodic table is color-coded by groups and subgroups. The legend indicates the following categories:

- State of matter (color of name):** GAS (red), LIQUID (orange), SOLID (blue), UNKNOWN (green).
- Subcategory in the metal-metalloid-nonmetal trend (color of background):** Alkali metals (red), Alkaline earth metals (orange), Transition metals (blue), Lanthanides (green), Actinides (red), Post-transition metals (blue), Metalloids (yellow), Reactive nonmetals (green), Noble gases (purple).
- Unknown chemical properties:** Indicated by a grey background.

1 IA 1 H Hydrogen 1.008 1	2 IIA 4 He Helium 4.003 2	3 IIIB 9 Sc Scandium 44.956 21	4 IVB 10 Ti Titanium 47.88 22	5 VB 11 V Vanadium 50.942 23	6 VIB 12 Cr Chromium 51.996 24	7 VIIB 13 Mn Manganese 54.938 25	8 VIII 14 Fe Iron 55.845 26	9 VIII 15 Co Cobalt 58.933 27	10 VIII 16 Ni Nickel 58.693 28	11 IB 17 Cu Copper 63.546 29	12 IIB 18 Zn Zinc 65.38 30	13 IIIA 19 Ga Gallium 69.723 31	14 IVA 20 Ge Germanium 72.63 32	15 VA 21 As Arsenic 74.922 33	16 VIA 22 Se Selenium 78.96 34	17 VIIA 23 Br Bromine 79.904 35	18 VIIIA 24 Kr Krypton 83.80 36	19 IIA 37 Rb Rubidium 85.468 37	20 IIA 38 Sr Strontium 87.62 38	21 IIIB 39 Y Yttrium 88.906 39	22 IVB 40 Zr Zirconium 91.224 40	23 VB 41 Nb Niobium 92.906 41	24 VIB 42 Mo Molybdenum 95.94 42	25 VIIB 43 Tc Technetium 98 43	26 VIII 44 Ru Ruthenium 101.07 44	27 VIII 45 Rh Rhodium 102.905 45	28 VIII 46 Pd Palladium 106.42 46	29 IB 47 Ag Silver 107.868 47	30 IIB 48 Cd Cadmium 112.411 48	31 IIIA 49 In Indium 114.818 49	32 IVA 50 Sn Tin 118.710 50	33 VA 51 Sb Antimony 121.757 51	34 VIA 52 Te Tellurium 127.6 52	35 VIIA 53 I Iodine 126.905 53	36 VIIIA 54 Xe Xenon 131.29 54	37 IIA 55 Cs Cesium 132.905 55	38 IIA 56 Ba Barium 137.327 56	39 IIIB 57-71 La Lanthanides	40 IVB 72 Hf Hafnium 178.49 72	41 VB 73 Ta Tantalum 180.948 73	42 VIB 74 W Tungsten 183.84 74	43 VIIB 75 Re Rhenium 186.207 75	44 VIII 76 Os Osmium 190.23 76	45 VIII 77 Ir Iridium 192.222 77	46 VIII 78 Pt Platinum 195.084 78	47 IB 79 Au Gold 196.967 79	48 IIB 80 Hg Mercury 200.59 80	49 IIIA 81 Tl Thallium 204.384 81	50 IVA 82 Pb Lead 207.2 82	51 VA 83 Bi Bismuth 208.98 83	52 VIA 84 Po Polonium 209 84	53 VIIA 85 At Astatine 209 85	54 VIIIA 86 Rn Radon 222 86	55 IIA 87 Fr Francium 223 87	56 IIA 88 Ra Radium 226 88	57-71 IIIB 89-103 Ac Actinides	58 Lanthanum 138.905 58	59 Cerium 140.12 59	60 Praseodymium 140.908 60	61 Neodymium 144.24 61	62 Promethium 144.913 62	63 Samarium 150.36 63	64 Europium 151.964 64	65 Gadolinium 157.25 65	66 Terbium 158.925 66	67 Dysprosium 162.50 67	68 Holmium 164.930 68	69 Erbium 167.259 69	70 Thulium 168.930 70	71 Lutetium 174.967 71	72 Hafnium 178.49 72	73 Tantalum 180.948 73	74 Tungsten 183.84 74	75 Rhenium 186.207 75	76 Osmium 190.23 76	77 Iridium 192.222 77	78 Platinum 195.084 78	79 Gold 196.967 79	80 Mercury 200.59 80	81 Thallium 204.384 81	82 Lead 207.2 82	83 Bismuth 208.98 83	84 Polonium 209 84	85 Astatine 209 85	86 Radon 222 86	87 Francium 223 87	88 Radium 226 88	89-103 IIIB 89-103 Ac Actinides	89 Actinium 227 89	90 Thorium 232.038 90	91 Protactinium 231.036 91	92 Uranium 238.029 92	93 Neptunium 237.048 93	94 Plutonium 244.064 94	95 Americium 243.061 95	96 Curium 247.070 96	97 Berkelium 247.070 97	98 Californium 251.080 98	99 Einsteinium 252.083 99	100 Fermium 257.103 100	101 Mendelevium 258.103 101	102 Nobelium 259.103 102	103 Lawrencium 260.103 103	104 Rutherfordium 261.103 104	105 Dubnium 262.103 105	106 Seaborgium 263.103 106	107 Bohrium 264.103 107	108 Hassium 265.103 108	109 Tennessine 269.103 109	110 Oganesson 269.103 110
---	---	--	---	--	--	--	---	---	--	--	--	---	---	---	--	---	---	---	---	--	--	---	--	--	---	--	---	---	---	---	---	---	---	--	--	--	--	--	--	---	--	--	--	--	---	---	--	---	--	---	--	---	---	--	--	--	----------------------------------	------------------------------	-------------------------------------	---------------------------------	-----------------------------------	--------------------------------	---------------------------------	----------------------------------	--------------------------------	----------------------------------	--------------------------------	-------------------------------	--------------------------------	---------------------------------	-------------------------------	---------------------------------	--------------------------------	--------------------------------	------------------------------	--------------------------------	---------------------------------	-----------------------------	-------------------------------	---------------------------------	---------------------------	-------------------------------	-----------------------------	-----------------------------	--------------------------	-----------------------------	---------------------------	---	-----------------------------	--------------------------------	-------------------------------------	--------------------------------	----------------------------------	----------------------------------	----------------------------------	-------------------------------	----------------------------------	------------------------------------	------------------------------------	----------------------------------	--------------------------------------	-----------------------------------	-------------------------------------	--	----------------------------------	-------------------------------------	----------------------------------	----------------------------------	-------------------------------------	------------------------------------

Questions Using Elements of Reasoning

- Purpose
 - What am I trying to accomplish?
- Questions
 - What question am I raising or addressing?
 - Am I considering all the complexities?
- Information
 - What information or experience am I using?
 - What information do I need?
- Inferences/Conclusions
 - How did I reach this conclusion?
 - Is there another interpretation?



Questions Using Elements of Reasoning

- Concepts
 - What is the main idea?
 - Can I explain it?
- Assumptions
 - What am I taking for granted?
 - What have I assumed?
- Implications/Consequences
 - What am I implying?
- Points of View
 - What point of view am I using?
 - Is there another point of view to consider?



Intellectual Standards

- Clarity – Further elaboration, examples
- Accuracy – Verify, check out
- Precision – More specific, further details
- Relevance – Relate to question
- Depth – Complexities and difficulties
- Breadth – Another perspective, other point of view
- Logic – Makes sense, conclusions follow evidence
- Significance – Central idea, most important facts
- Fairness – Vested interest in the issue



Applying Standards to Elements of Reason

- Intellectual Standards should be applied to Elements of Reason.
- This approach can be used to:
 - Analyze contents of an article.
 - Analyze and assess research.
 - Help you formulate your own conclusions.
 - Help you take a reasoned stand on an issue.
- This leads to developing Intellectual Traits.



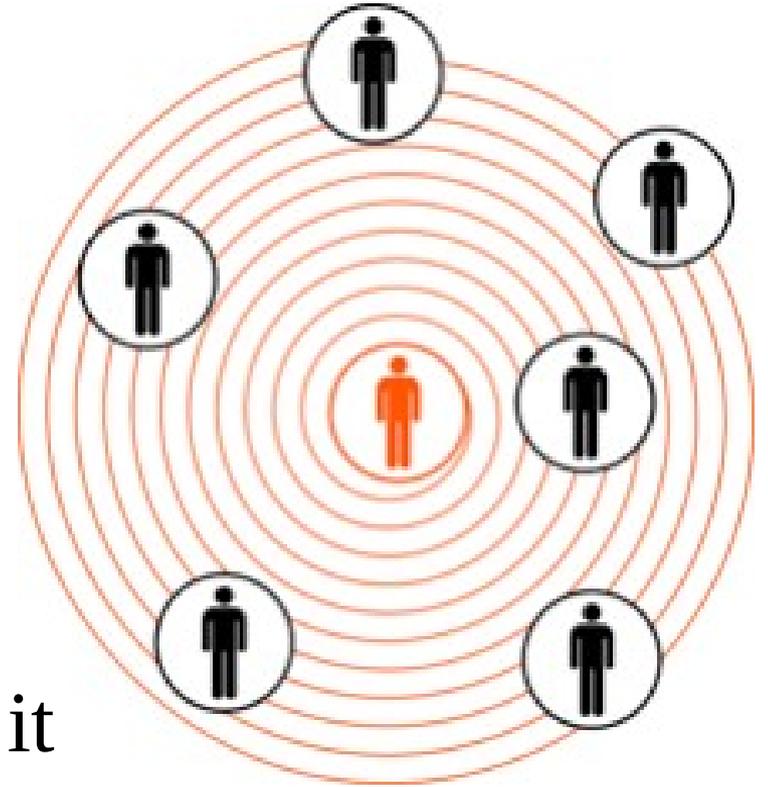
Intellectual Traits

- Intellectual Humility - Realize limits of own knowledge
- Intellectual Courage - Ideas/beliefs/views that counter our own
- Intellectual Empathy - See the other side
- Intellectual Autonomy - Think for yourself
- Intellectual Integrity - Hold yourself to consistent, high standards
- Intellectual Perseverance - Work through confusion
- Confidence in Reason - Believe that high standards will win out
- Fair-mindedness - Treat all viewpoints alike

Egocentric Thinking

It's true because:

- I believe it
- We believe it
- I want to believe it
- I have always believed it
- It is in my own interest to believe it



Apply Critical Thinking to Weather Modification

- Elements of Reasoning
- Intellectual Standards
- Applying Standards to Elements of Reason
- Intellectual Traits
- Taking Action without Egocentric Thinking



Image from cloud seeding in North Dakota on July 2, 2012. Credit: David Delene