Escape by Thinking

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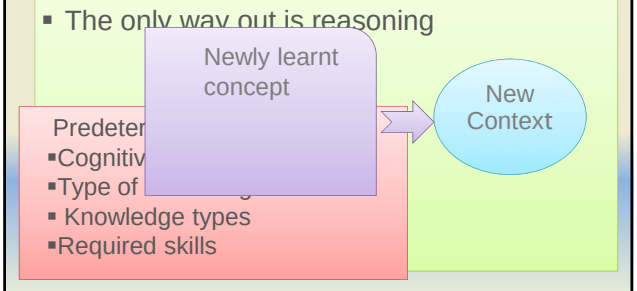
"Teaching is the art of leading students into a situation in which they can only escape by thinking."
Dr. C. T. Bassoppo-Moyo

Introduction– What is Content Question

- Open ended question
- The only way out is reasoning



Scientific reasoning

- Proportional Reasoning
- Controlling Variables
- Combinational Reasoning
- Correlation Reasoning
- Analogical Reasoning
- Probabilistic Reasoning
- Causal-effect Reasoning

Lawson's test of formal reasoning

- The conservation of weight
- Displaced volume
- Proportional Reasoning
- Controlling Variables
- Combinational Reasoning
- Probabilistic reasoning

Levels of Reasoning

Concrete

Transitional

Formal

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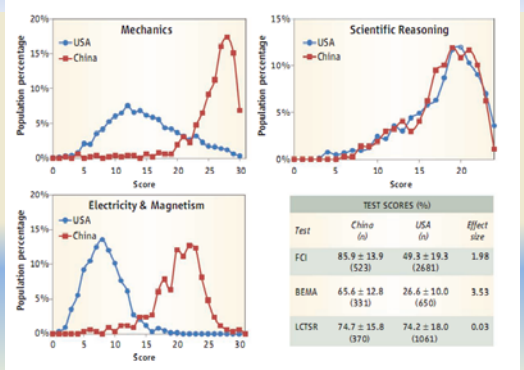
Learning and Scientific Reasoning [1]



1- Bao et. al (2009)

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Bloom's revised taxonomy for classifying the components of reasoning [1]

Table 1- Selection from Knowledge Dimension

Factual knowledge	Knowledge of elements and essential facts
Conceptual knowledge	Knowledge of classification ,principles , theories and structures, Conceptual schema
Procedural knowledge	Knowledge of subject-specific skills, algorithms, techniques, methods and procedures

1-Anderson et. al, 2001

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Bloom's revised taxonomy for classifying the components of reasoning, Cont.

Table 2- Selection from Cognitive Dimension

Remember	Recognize (identify), Recall (retrieve from memory)
Understand	Interpret (paraphrase, change representation), Infer (draw logical conclusion), Classify (categorize),Compare and Contrast, Explain (construct cause and effect model)
Apply	Implement (apply a procedure to an unfamiliar task), Execute (apply a procedure to a familiar task)

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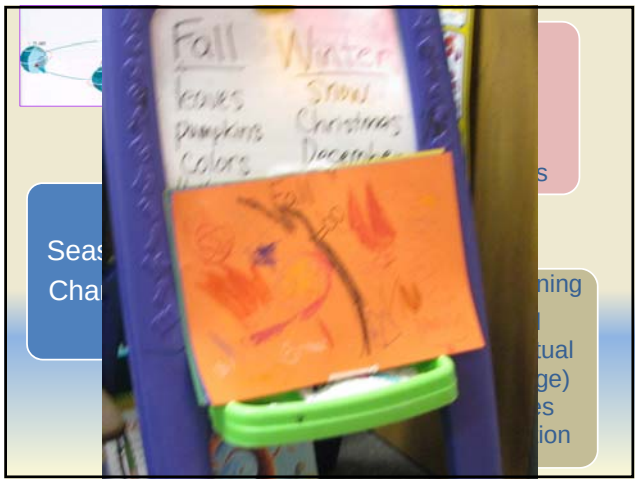
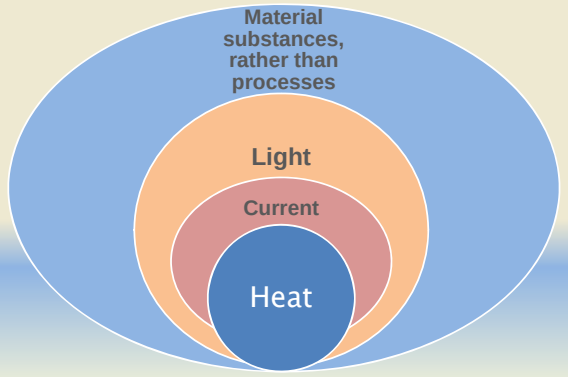


Example of difficulty in classification [1]



1-Chi and Slotta and deLeeuw (1994)

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Changing a recall question to content question

- Explain why the weight of a person on the surface of Earth from ld be n.

Facts

Recall

- Explain how astronauts eat and go to the bathroom in space?
- Discuss the problems that may o techniques suggest to problems.

Conceptual

Apply

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Content questions and NSEUS[1] Project

- Compare students' scientific reasoning across disciplines (Elementary education majors)
- Comparison between students of NOVA[2] (active based learning) and NON-NOVA (traditional) courses
  - Chemistry, Biology, Geology, Physics, Astronomy, Microbiology

1- National Study of Education in Undergraduate Science
2- NASA Opportunities for Visionary Academics

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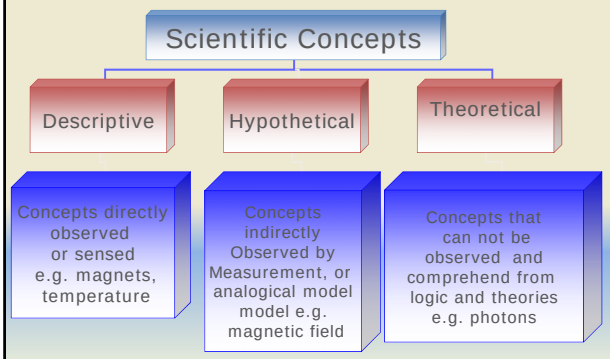
Modification to Lawson's[2] definition to make it appropriate for physics contexts



2-Lawson et. al (2000)

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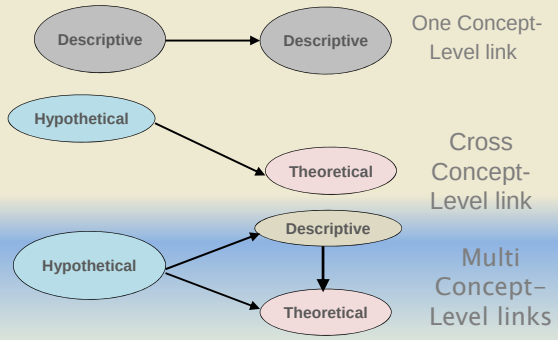
Type of concept links[3]



3-Neiswandt & Bellemo 2009

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Rubric

- Interpret students' responses in terms of components of Bloom's revised taxonomy
- Construct a fra levels of perfor *Naïve)*[1] for eac Taxonomy
- Identify studen each compone definitions

Identify type of concepts and concept links

1-Wiggins and J. McTighe (1998)

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Transforming to content question

Explain the difference Between covalent band and ionic band?

- In the winter time spreading salt on the road can melt ice. Explain how the chemical structure of salt affects the properties of the solution? And why sugar, does not have the same effect?

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Example answer and chain of reasoning

"When ice and water come into contact with each other one is going through a process of freezing while the other is going through the process of melting. The rate of freezing happens to be the same as the rate of melting, thus they are at equilibrium with each other. When salt is added, the equilibrium is then disrupted. The salt is dissolved in the water making there be fewer water molecules in the liquid side. The total number of waters captured by the ice per second goes down, thus the rate of freezing decreases. The rate of melting remains the same, so melting occurs faster than freezing……

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…….Sugar is another substance that can be dissolved in water. Sugars can be used to lower water's freezing temperatures however, it does not have the same effect as salt does because unlike salt, salt's lower molecular weight gives it almost six times the effectiveness of sugar in lowering the freezing point of water. Another good reason is because salts are electrolytes while sugar is not at all……

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…….When the salt is combined with the water, the rate of freezing decreases due to the salt creating fewer water molecules on the liquid side so the total number of waters captured by the ice per second decreases dramatically and has the fastest effect in melting the ice on roads. With sugars, the exact same process occurs but at a much slower rate because of the sugars molecular weight, thus the effectiveness and outcome is not as great as the salt's effectiveness".

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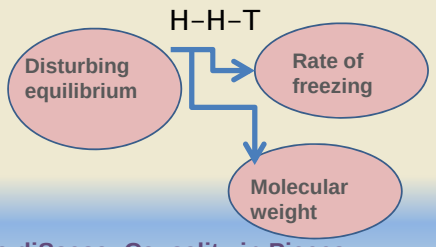
Chain of Reasoning



Andrea diSsesa- Causality in Pieces

Balance out=big deal Degree of imbalance/activation

Agency (freaking out, work harder) *higher agency*

Close to equilibrium (calm down) *lower agency*

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Factual=?

Conceptual=?

Compare=?

Infer=?

Factual=1

Conceptual=1

Compare=2

Infer=1

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Biology Question

a)You are given four plants with different seed pods and flower colors (Yellow and white). You breed the plant with the swollen pods and yellow flowers to the plant with pinched pods and yellow flowers. The result is some plants with swollen pods and white flowers and others with swollen pods and yellow flowers. Predict which trait is dominant and recessive?

b)Next you breed a plant with pinched pods and yellow flowers to a plant with pinched pods and white flowers. The result is all plants with pinched pods and white flowers. Does this result support your hypothesis? Explain

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SS + pp = SS
Sp + pp = Sp + pp

Ps + ss= Ps + ss

YY + ww= YY
Yw + ww= Yw + ww
Yw + Yw= Yw + ww

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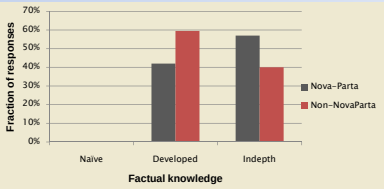
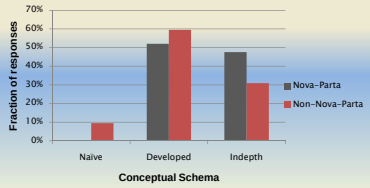
Factual	***Heterozygous, homozygous, recessive, and dominant***
Conceptual	***Interaction between member alleles of the pair that produce outcome pair of alleles***
Classification	***Probable occurrences of phenotypes Combinations of two types of alleles***
Procedure	***Rules of multiplying probabilities for two independent variable***
Compare	***Comparing the occurrence of the cross with all possible outcomes of the combinations to predict type of alleles***
Infer	***Justify how and why cause related to the effect***
Apply	***Apply the multiplication rule of probability to the cross of two traits to interpret the***

Type of Reasoning	Rubric	Concept link
"Yellow is dominant and swollen is dominant"	Naive	T,D
"I predict that swollen are dominant and white is recessive because you had no pinched pods after the cross and still have yellow flowers"	Factual, Conceptual, (Developed) Others(Naïve)	T-D
"Both swollen pods and white flowers are dominant. Swollen pods are present in all offspring while pinched are not. White flowers come from the recessive-recessive of the yellow"	Factual, Conceptual Classification, Infer Compare (Developed) Apply, Procedural (Naïve)	T-D, T-T-D
"When both yellow were breeded white did appear which seems to claim that only when 2 heterozygous plants cross the white recessive gene can appear"	In-depth	T-T-T

Comparing NOVA, N=21 and Non-NOVA N=42



Factual knowledge



Conceptual Schema

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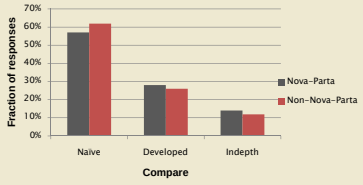
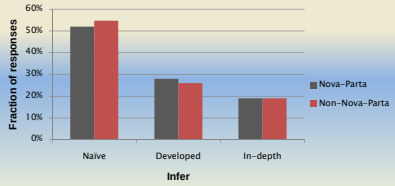


Compare



Infer

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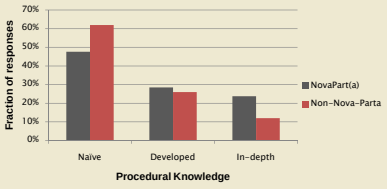
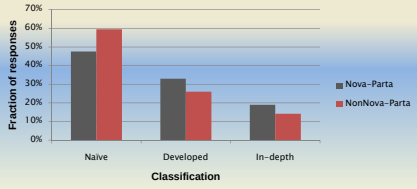


Procedural Knowledge



Classification

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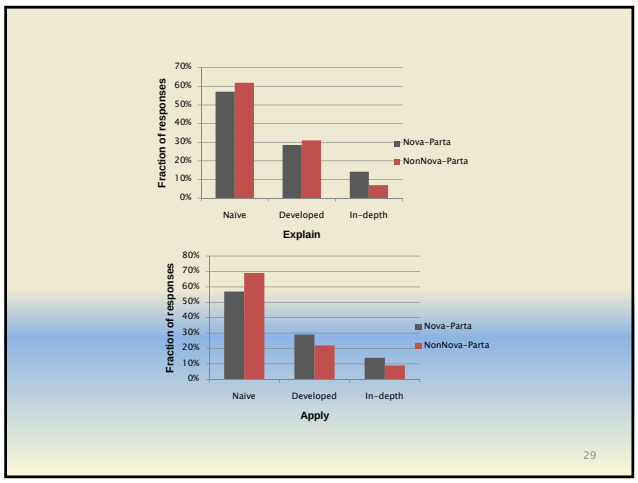
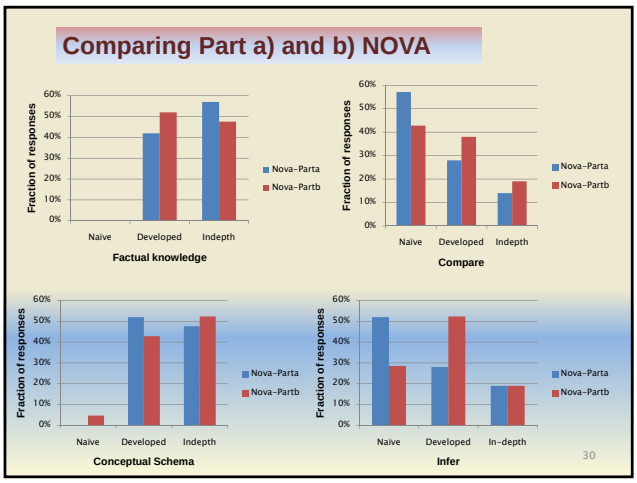
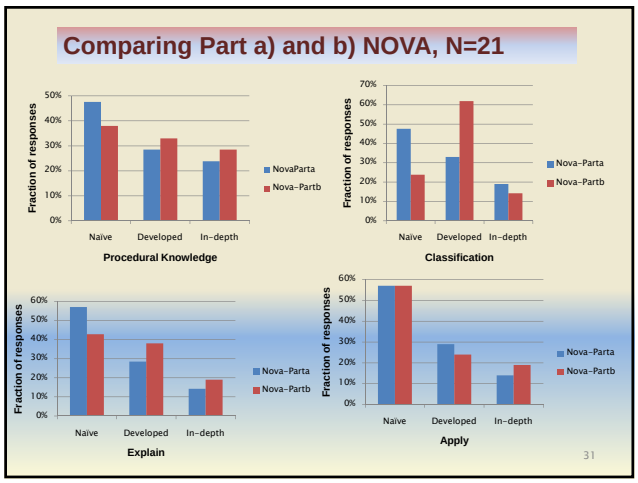

Fraction of responses
70%
60%
50%
40%
30%
20%
10%
0%
Naive
Developed
In-depth
Nova-Parta
NonNova-Parta
Explain
Fraction of responses
80%
70%
60%
50%
40%
30%
20%
10%
0%
Naive
Developed
In-depth
Nova-Parta
NonNova-Parta
Apply
29


Comparing Part a) and b) NOVA
Fraction of responses
60%
50%
40%
30%
20%
10%
0%
Naive
Developed
Indepth
Nova-Parta
Nova-Partb
Factual knowledge
Fraction of responses
60%
50%
40%
30%
20%
10%
0%
Naive
Developed
Indepth
Nova-Parta
Nova-Partb
Compare
Fraction of responses
60%
50%
40%
30%
20%
10%
0%
Naive
Developed
Indepth
Nova-Parta
Nova-Partb
Conceptual Schema
Fraction of responses
60%
50%
40%
30%
20%
10%
0%
Naive
Developed
In-depth
Nova-Parta
Nova-Partb
Infer
30


Comparing Part a) and b) NOVA, N=21
Fraction of responses
50%
40%
30%
20%
10%
0%
Naive
Developed
In-depth
NovaParta
Nova-Partb
Procedural Knowledge
Fraction of responses
70%
60%
50%
40%
30%
20%
10%
0%
Naive
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Nova-Parta
Nova-Partb
Classification
Fraction of responses
60%
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30%
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10%
0%
Naive
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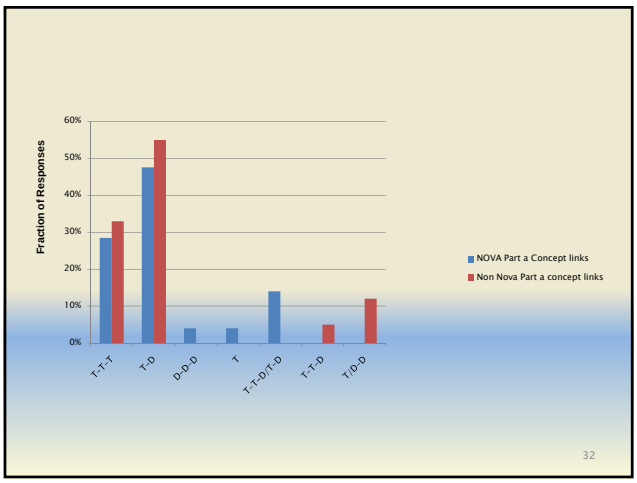
In-depth
Nova-Parta
Nova-Partb
Explain
Fraction of responses
60%
50%
40%
30%
20%
10%
0%
Naive
Developed
In-depth
Nova-Parta
Nova-Partb
Apply
31


Fraction of Responses
60%
50%
40%
30%
20%
10%
0%
T-T-T
T-D
D-D-D
T
T-T-D/T-D
T-T-D
T/D-D
NOVA Part a Concept links
Non Nova Part a concept links
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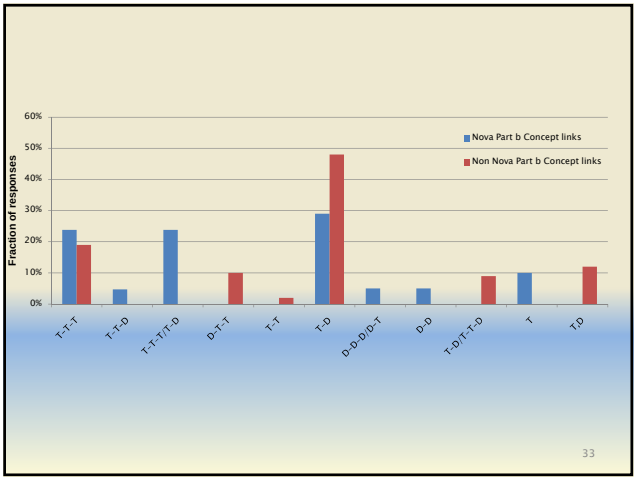

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Conclusion

- ✓We can find the weaknesses and strengths of students' reasoning in our classification scheme(concept structure, type of knowledge or cognitive process)
- ✓NOVA students outperformed the Non-NOVA for some types of knowledge
- ✓Students' performance decline when the higher hierarchies of knowledge is required
- ✓As the answers display in-depth level of knowledge the conceptual structure is more shown to be multi-level link

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Future; Evaluate, Escape by thinking☹

Roam of thinking limited, no alternative way,	**Bio Question**
Some students' escaped Not clear reasoning occurred	**Toy ship Question**
Procedural knowledge and knowledge of classification are not included	**Ionic bonds**
Concept links not similar, application of concept different, Prior knowledge, Asking every step	**General notes**

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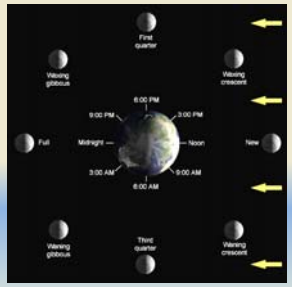
Next☺ Astronomy Question

- Is the length of time that the moon is above the horizon the same for different phases of the moon? Compare the length of time that the moon is above the horizon for three different phases of waxing crescent, first quarter and full moon. Explain why?



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Discussion Questions:

- Q1) You mention a framework in which the three levels of Bloom's Taxonomy are further subdivided into 'In-depth', 'Developed' and 'Naïve'. In what ways are the existing levels of Bloom's Taxonomy insufficient to characterize student knowledge and reasoning?
- Q2) What is the relationship between the kinds of links that students make (e.g. T-D, H-D, H-H-T etc.) and the three modified sub-levels of Bloom's classification (i.e. 'Naïve', 'Developed', 'In-Depth'). In other words, what criteria, based on the links that students demonstrate, do you use to categorize students as 'Naïve', 'Developed' and 'In-Depth'?

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