

# Education for Innovation

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# The Knowledge Society

... disparities in the productivity and growth of different countries have far less to do with their abundance (or lack) of natural resources than with the capacity to ... **create new knowledge and ideas** ... “the ‘need to innovate’ is growing stronger as innovation comes closer to being the sole means to survive and prosper in highly competitive and globalised economies.”

# Knowledge Creation

Scientists, scholars, and employees of highly innovative companies engage in **knowledge building** as a normal part of their work. A growing number of innovative teachers are creating knowledge building communities in their classrooms, and demonstrating significant advances in science, math, basic literacy, along with graphical and computer literacy and a host of 21st-century abilities such as team-work, problem solving, idea creation and improvement.

# How Can Schools Increase People's Abilities to Create Knowledge?

- The **popular answer: Develop skills**, personal characteristics, habits of mind, and attitudes conducive to knowledge creation.
- There are no tested or even very plausible ways of achieving these objectives.
- The **Knowledge Building** alternative: Learn to create knowledge by actually doing it.
- This requires finding ways to **support novices in carrying out knowledge creation**.

# Knowledge Building

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Distinction between learning and knowledge building is understood in business contexts--what goes on in one's head versus additions to the organization's "knowledge capital."

Medical students--know the difference and believe they are not ready for it

"I'm learning now--I'll be more creative with ideas when I have more of **the basics.**"

# Developmental trajectory for knowledge-creating environments

	Characteristics of knowledge-creating organizations	
21 <sup>st</sup> century skills	Entry level	High
<b>Creativity and innovation</b>	<b>Internalize given information;</b> beliefs/actions based on the assumption that <b>someone else [Internet] has the answer</b> or knows the truth	<b>Work on unsolved problems;</b> generate theories and models, take risks, etc.; pursue <b>promising ideas</b> and plans
<b>Communication</b>	Social chitchat; discourse that aims to get <b>everyone to some predetermined point;</b> limited context for peer-to-peer or extended interactions	Discourse aimed at <b>advancing the state of the field,</b> and at achieving a more inclusive, higher-order analysis; open spaces encourage peer-to-peer and extended interactions

# Developmental trajectory for knowledge-creating environments

	Characteristics of knowledge-creating organizations	
21 <sup>st</sup> century skills	Entry level	High
<b>Collaboration/ teamwork</b>	<b>Small group work:</b> divided responsibility to create a finished product; the whole is the sum of its parts, not greater than that sum	<b>Shared intelligence</b> from collaboration and competition enhances existing knowledge. Individuals interact productively and work with networked ICT. <b>Advances in community knowledge are prized over individual success</b> , while enabling each to contribute to it
<b>Information literacy/research</b>	<b>Inquiry: question-answer, through finding and compiling information;</b> variable testing research	Collaborative expansion of <b>social pool of improvable ideas</b> , with research integral to efforts to advance knowledge

## Developmental trajectory for knowledge-creating environments

	Characteristics of knowledge-creating organizations	
21 <sup>st</sup> century skills	Entry level	High
<b>Critical thinking, problem solving, and decision making</b>	<b>Meaningful activities are designed by the director, teacher, or curriculum designer</b> ; learners work on predetermined tasks set by others	High-level thinking skills exercised in authentic knowledge work; <b>the bar for accomplishments is continually raised by participants as they engage in complex problems and systems thinking</b>
<b>Citizenship—local and global</b>	Support of organization and community behavioral norms; <b>“doing one’s best”</b> ; <b>personal rights</b>	Citizens feel part of a knowledge-creating civilization and aim to <b>contribute to a global enterprise</b> ; they value diverse perspectives, build shared knowledge in formal and informal settings, exercise leadership, and <b>support inclusive rights</b>

## Developmental trajectory for knowledge-creating environments

	Characteristics of knowledge-creating organizations	
21 <sup>st</sup> century skills	Entry level	High
<b>ICT literacy</b>	Familiarity with and ability to <b>use common applications</b> and web resources and facilities	ICT integrated into organization's daily work; shared <b>community spaces built and continually improved by participants</b> , with connection worldwide
<b>Life and career skills</b>	<b>Personal career goals</b> consistent with individual characteristics; realistic assessment of requirements and probabilities of achieving career goals	Engagement in continuous, "life- long," and "life-wide" learning opportunities; <b>self-identification as a knowledge creator, regardless of life circumstance or context</b>

# Developmental trajectory for knowledge-creating environments

	Characteristics of knowledge-creating organizations	
21 <sup>st</sup> century skills	Entry level	High
<b>Learning to learn/metacognition</b>	<b>Students and workers provide input</b> to the organization, but the high-level processes are under the control of someone else	<b>Students and workers are able to take charge at the highest, executive levels;</b> assessment is integral to the operation of the organization, requiring social as well as individual metacognition
Personal and social responsibility— incl. cultural competence	Individual responsibility; local context	Team members build on and improve the knowledge assets of the community, with appreciating cultural dynamics that allow the ideas to be used and improved for benefit of multicultural, multilingual, changing society

# Knowledge Building

Refashion education in a fundamental way, so that it becomes a coherent effort to initiate students into a knowledge creating culture.

Students come to see themselves and their work as part of the civilization-wide effort to advance knowledge frontiers.

# Knowledge Building

Member of the large family of constructivist approaches to education

If compelled to put into one sentence what is different:  
*giving students collective responsibility for idea improvement*

# ***Collective* responsibility implies something beyond responsibility for improvement of ones personal knowledge and ideas.**

In order for the group to exercise epistemic agency collectively, ideas must be treated as having an out-in-the-world existence.

They are not equivalent to personal beliefs or notions, but are more like the theories and inventions that have a public life in knowledge-based organizations and societies.

# **The Quickest way to a Knowledge Building Community**

Get students committed to improving their theories, in a community of students committed to advancing not only their own ideas but those of the community as a whole.

# Take Risks with Ideas; Improve Your Ideas

- No finality in theory or design
- Problem solutions raise new problems and opportunities
- Lakatos, History of Science: Progressive vs. degenerative programs
- Treating ideas as artifacts

# Beyond Best Practice

Best practice and evidenced-based practice broadly accepted as a way to foster engagement with principles

## Beyond Best Practice

--not satisfied with individualized instruction, want deeply personalized  
--not satisfied with students as collaborators but students able to take responsibility.

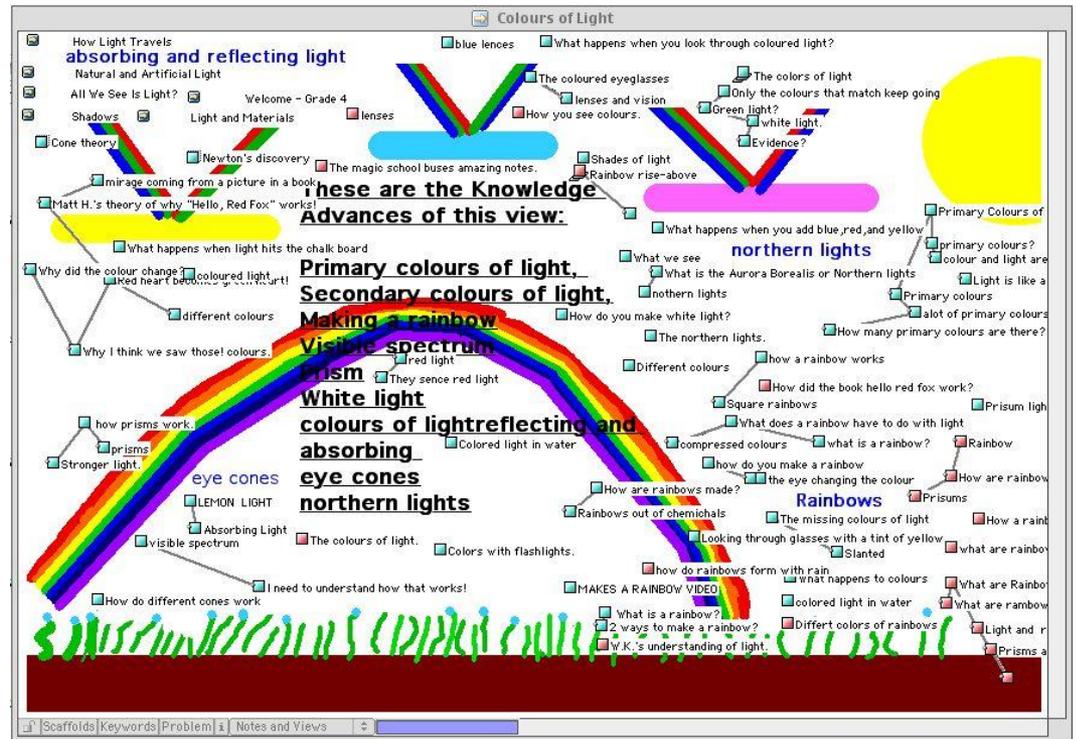
## Case Study of Going Beyond Best Practice

--innovation at all levels (teacher, student, assessment, professional development)

--starting point = best practice—small group work, attention to high-level knowledge processes, student responsibility,

# Context: Science Learning

- A teacher working with three classes of fourth-graders over three years
- Unit = optics



Light and rainbows - S.L.

COI Journal

- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- My Theory
- I Need To Under
- Long Range Goal

Problem What are Rainbows made out of?

**Natalie** Light is made of the colours the rainbow put together and that is why you can see a rainbow when you hold a prism up to regular light. My question is that what splits up the light to make a rainbow.

Keywords light, prism, rainbow, regular, split

Add - - >

Scaffolds Build On i Connections

Close

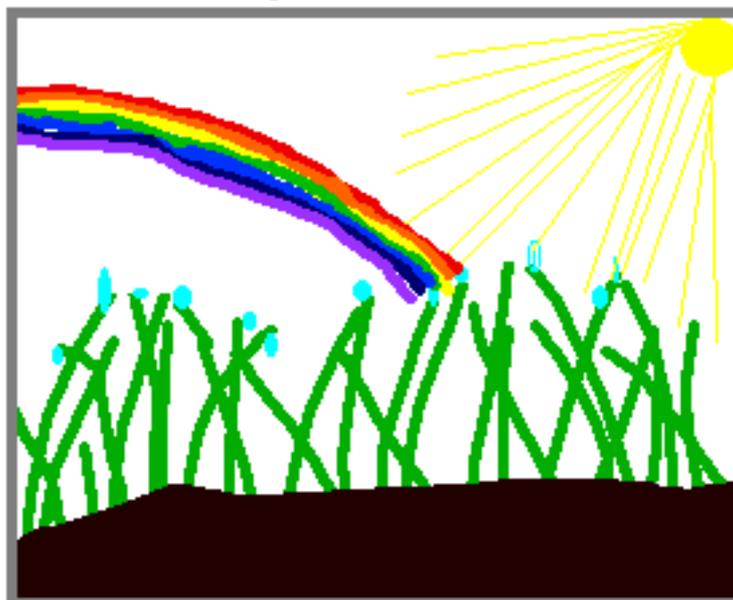
COI Journal

Problem What are Rainbows made out of?

- Monday
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- Monday
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- Wednesday
- Thursday
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- Long Range Goal

**My theory** is that the sun shines through the raindropps after storms that reacts as prisms that make a rainbow.



Keywords careful, clearer, form, rain, rainbows, sky

Add - - >

Scaffolds Build On i Connections

Close

The screenshot displays a multi-windowed software interface. At the top, a window titled "Light and rainbows - S.L." is partially visible. Below it, a window titled "Rainbow - K.L." contains a "Problem" field with the text "What are Rainbows made out of?". The main content area of this window shows a journal entry for "Monday" with the text: "My theory is that the sun shines".

Overlaid on this is a smaller window titled "How are rainbows made - S.L.". It also has a "Problem" field with the same text: "What are Rainbows made out of?". The main content area of this window contains a text entry: "It's very hard to beleive that a big thing like a rainbow can be 'activated' by mere raindrops. Do you think that there might be something else? Maybe it's because of the moisture in the air." The word "rainbow" is highlighted in green in the original image. Below the text is a "Keywords" field containing the text: "activated, careful, clearer, form, mere, moisture, rain, rainbow, rainbows, raindrops, sky".

At the bottom of the interface, another window is partially visible, showing a "Keywords" field with the text: "careful, clearer, form, rain, rainbows, sky".

On the left side of the interface, there is a vertical navigation menu with the following items: "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "My Theory", "I Need To Under", and "Long Range Goal".

At the bottom of the windows, there are navigation buttons: "Add -->", "Scaffolds", "Build On", "Connections", and "Close".

Light and rainbows - S.L.

COI Journal

Problem What are Rainbows made out of?

**My theory is that the sun shines**

How are rainbows made - S.L.

COI Journal

Problem What are Rainbows made out of?

Differt colors of rainbows - Katlyn

COI Journal

Problem RRainbow\$

**My problem of understanding**

**Matthew H. There are lots of colors of the rainbows why are they allways in the same order?**

Keywords

Scaffolds Build On i Connections Close

Add--> Scaffolds Build On i Connections Close

Monday  
Tuesday  
Wednesday  
Thursday  
Friday  
My Theory  
I Need To Under  
Long Range Goal

Monday  
Tuesday  
Wednesday  
Thursday  
Friday  
My Theory  
I Need To Under  
Long Range Goal

Monday  
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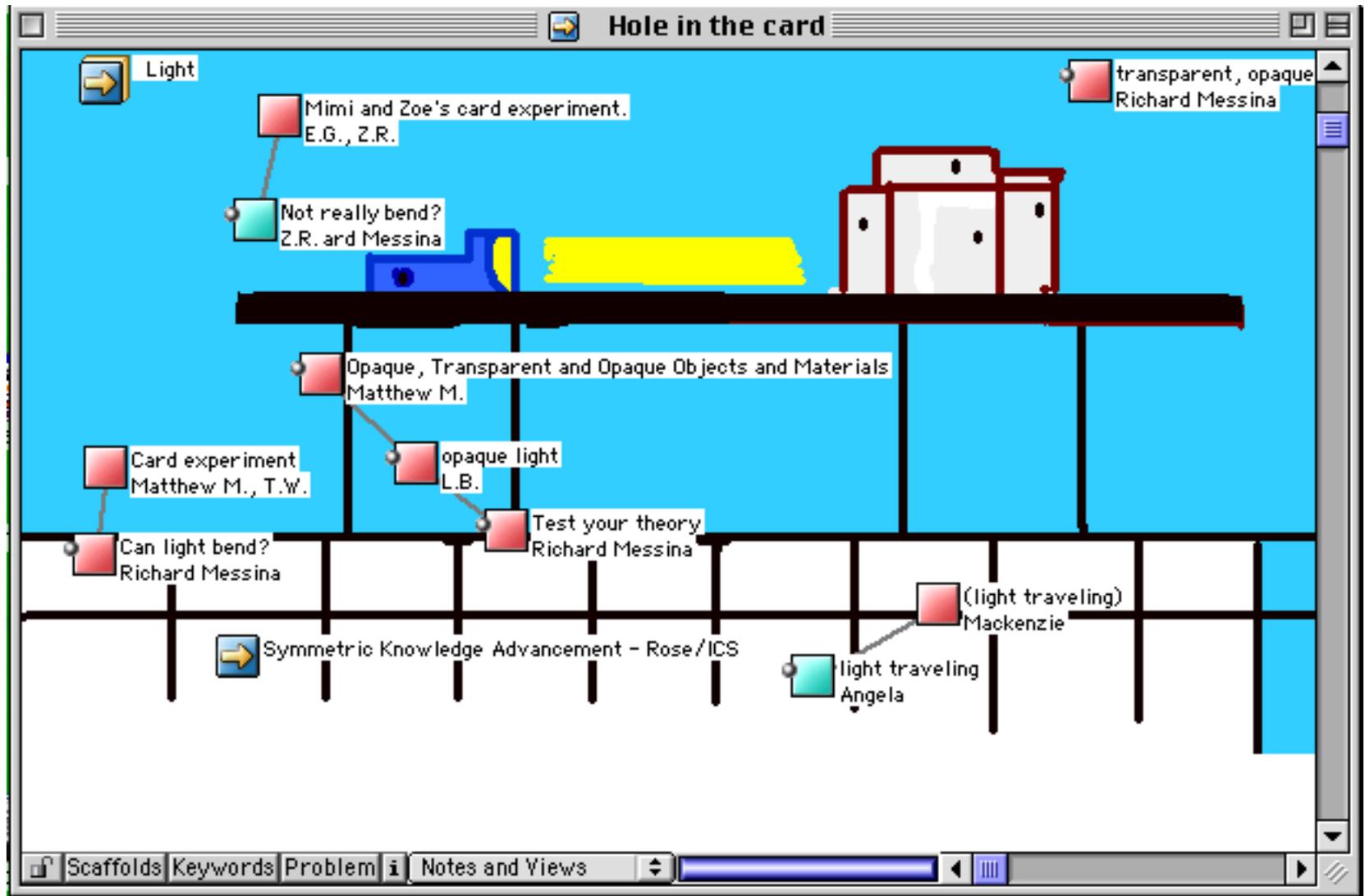
The image shows a screenshot of a learning management system with several overlapping windows. The top window is titled "Light and rainbows - S.L." and contains a "COI Journal" sidebar with a list of days: Monday, Tuesday, Wednesday, Thursday, Friday, My Theory, I Need To Under, and Long Range Goal. The main content area of this window has a "Problem" field with the text "What are Rainbows made out of?" and a text box containing the sentence "My theory is that the sun shines".

The second window, titled "Rainbow - K.L.", is partially obscured and shows a "Problem" field with "What is a rainbow?" and a text box with the text "The sun shines through the water droplets that act like a prism. The colors that are visible are called the VisibleSpectrum. Diffrent colors of light travles in diffrent speeds." Below this text is a "Keywords" field containing "colors, droplets, light, prism, slowest, sun, traules, violet, VisibleSpectrum, water." and a footer with "Add--> Scaffolds Build On i Connections Close".

The third window, titled "How are rainbows made - S.L.", is also partially obscured and shows a "Problem" field with "What is a rainbow?" and a text box with the text "of the in the". Below this text is a "Keywords" field and a footer with "Add--> Scaffolds Build On i Connections Close".

The fourth window, titled "How a rainbow works - K.L., Rebecca", is partially obscured and shows a "Problem" field with "What is a rainbow?" and a text box with the text "of the in the". Below this text is a "Keywords" field and a footer with "Add--> Scaffolds Build On i Connections Close".

# Experiments in the Database



## The Order of the Rainbow - Alyssa

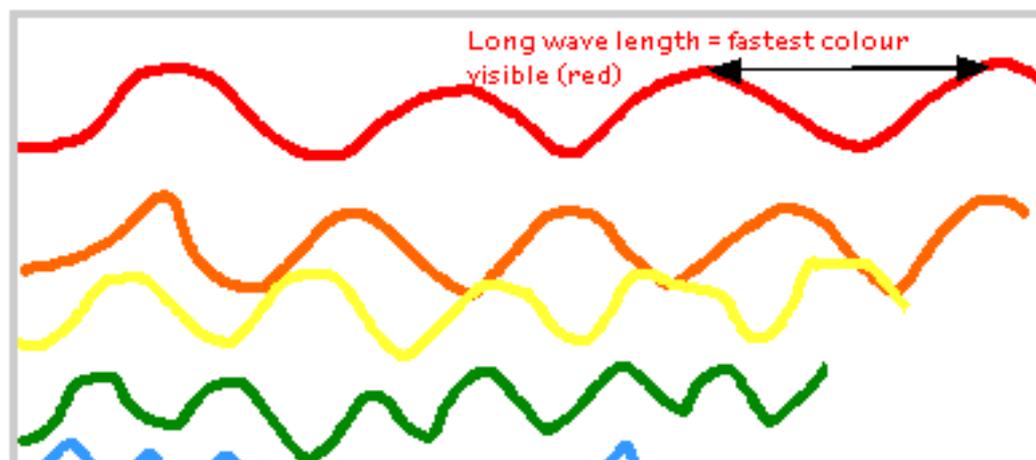
**Problem** Why are the colours of the rainbow always in a specific order?



**Our Problems** why the colours of a rainbow are always in a specific order? 1

### Putting our knowledge together

we have figured out the answer to this question. The colours of the rainbow are always in a specific order because of the subject that we are studying, light frequencies. We will explain more clearly. Different light frequencies make different colours. Red has the longest wavelengths and travels the fastest. Violet has the shortest wavelength and travels the slowest. Red always gets its place first in the rainbow because it travels faster than all the other colours. Violet is always last because it travels slower than all the other colours. The colours in between come in order from the longest frequencies to the shortest frequencies. The specific order that the rainbow is in is red, orange, yellow, green, blue, indigo, violet. An easier way to remember that is Mr. Roy G. Biv. The "R" stands for red, the "O" stands for orange, the "Y" stands for yellow, the "G" stands for green the "B" stands for blue the "I" stands for indigo and the "V" stands for violet. So the colours of the rainbow are always in the same order.



Keywords r0

Scaffolds Build-on i

### Rise Above

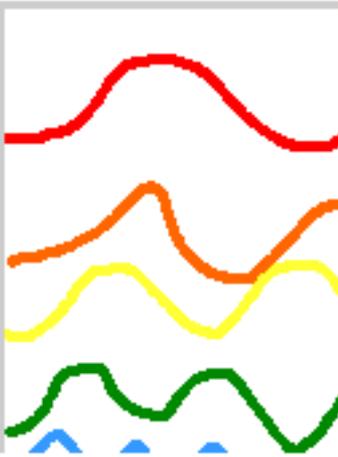
Icon	Title	Authors	Date
Note	Problem	Keywords	Custom
Why are the clours in a rainbow always...	Alyssa		
•differnt coluers	Ben		
•red,orange and yellow are warm.	Scott		
•Colours of the Rainbow in a Different Order?	Thando		
•I disagree	Scott		

Clear All Delete

Problem why are the colour

 Our Problems wh

Putting our knowledge toge  
we have figured out the ans  
subject that we are studyin  
colours . Red has the longes  
Red always gets it's place f  
it travels slower than all t  
frequencies. The specific o  
remember that is Mr. Roy  
for green the "B" stands fo  
always in the same order.



Keywords m=0

Scaffolds Build-on i

Clear All Delete

Our Problems *why the colours of a rainbow are always in a specific order*

We have figured out an answer... Different light frequencies make different colours. Red has the longest wavelength and travels the fastest. Violet has the shortest... Red always gets its place first in the rainbow because it travels faster.... Violet is always last because it travels slower than all the other colours. The colours in between come in order from the longest frequencies to the shortest...

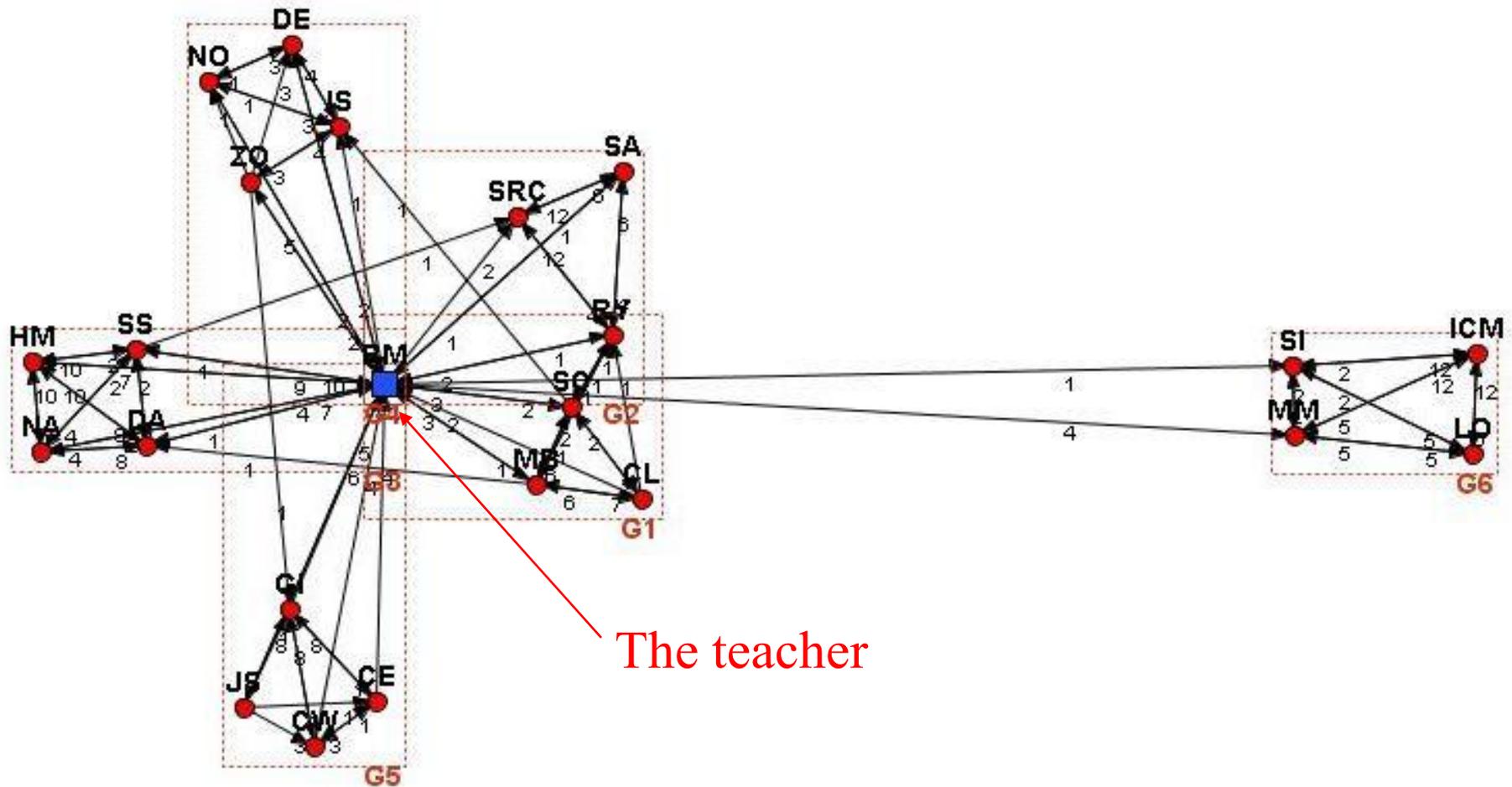
# Class Portfolio Views

The screenshot shows a software window titled "Light Learnings" with a blue background. At the top center, the text "OUR LIGHT LEARNINGS" is displayed in a large, stylized font. Below this, the word "Reflections." is visible. A "Welcome" button is located on the left. A "Portfolios Menu" button is positioned in the upper middle. The interface is organized into several sections, each with a thumbnail image and a descriptive text box:

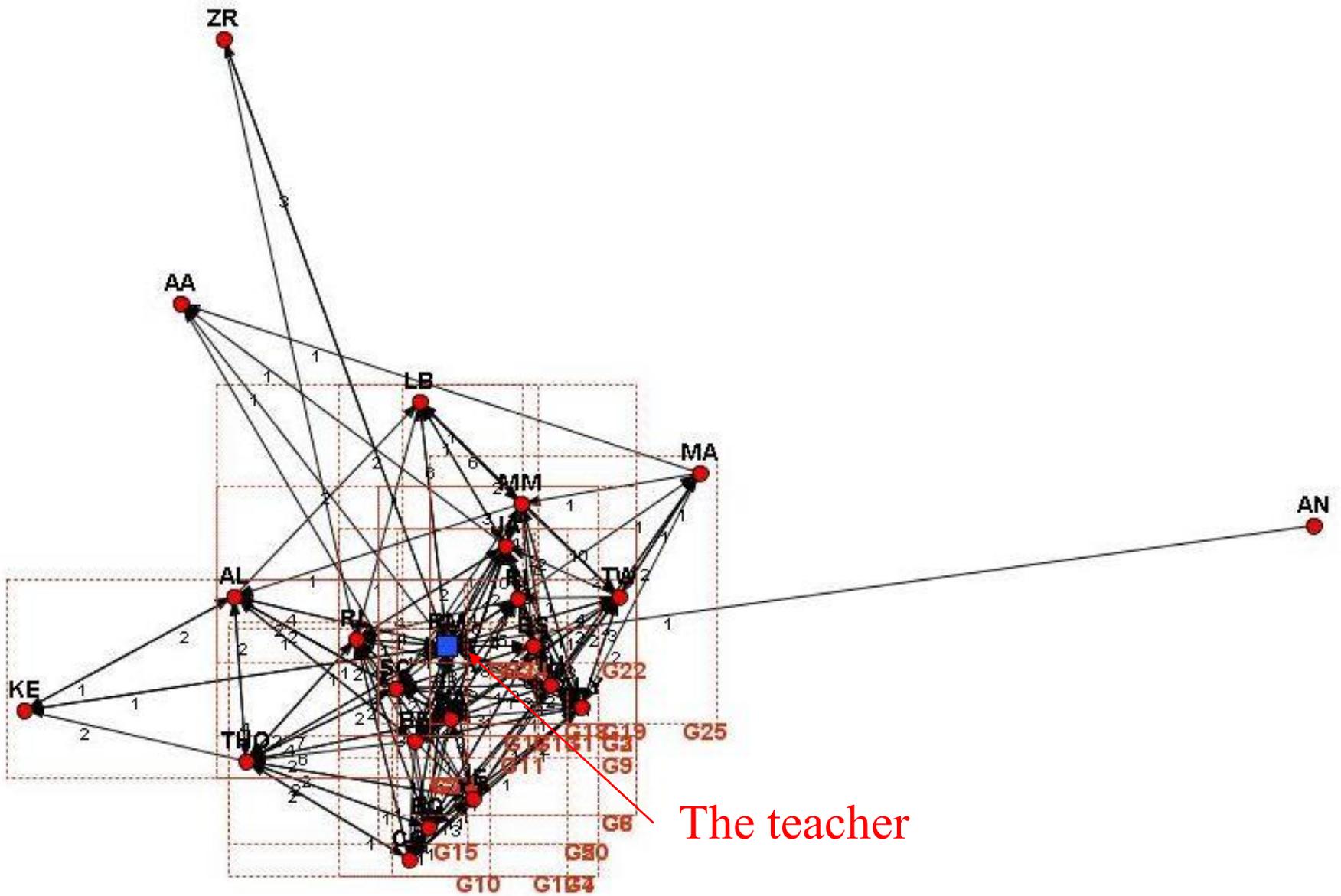
- Angles and Reflection:** A thumbnail showing a diagram of light rays reflecting off a surface. The text box below it reads "Our understanding of angles and reflections".
- Mirrors:** A thumbnail showing a green background with a blue circle and a red laptop icon. The text box below it reads "Our understanding of mirrors".
- Colours of Light:** A thumbnail showing a spectrum of colors and a prism. The text box below it reads "Our understanding of prisms".
- Colours of Opaque Objects:** A thumbnail showing a spectrum of colors and a red laptop icon. The text box below it reads "Our Understanding of Pigment and Light" and "Our Understanding of Colours of Opaque Objects".
- Images:** A thumbnail showing a dark background with various icons and text. The text box below it lists: "Our understanding of lenses", "Our understanding of Photographs", "Our understanding of Images", and "Our understanding of cameras".
- Sources of Light:** A thumbnail showing a dark background with various icons and text. The text box below it lists: "Our understanding of sources of light" and "Our understanding of luminous".

At the bottom of the window, there is a navigation bar with buttons for "Scaffolds", "Keywords", "Problem", "Notes and Views", and a scroll bar.

# Cliques (sub-communities)



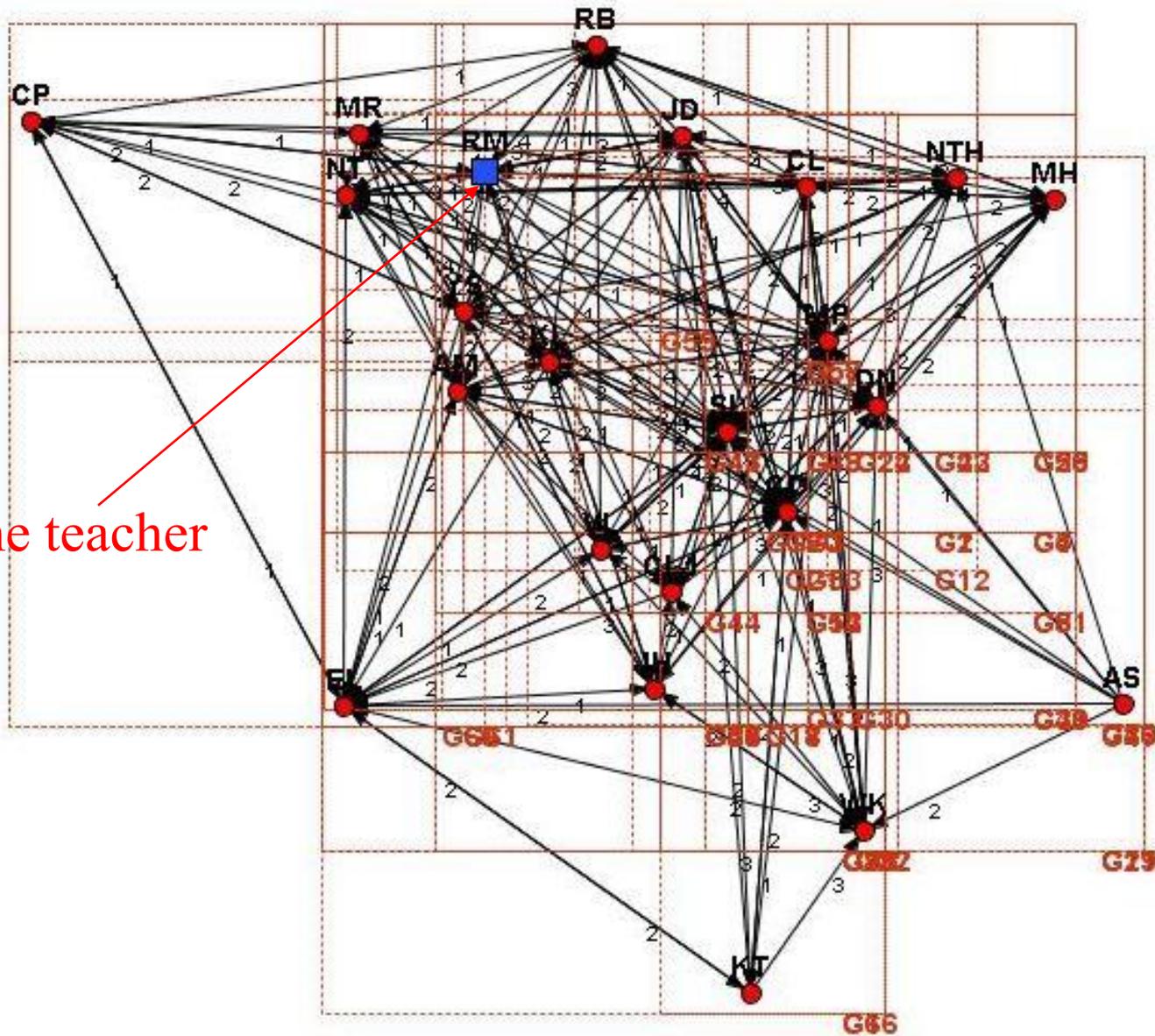
Year 1: Specialized-group



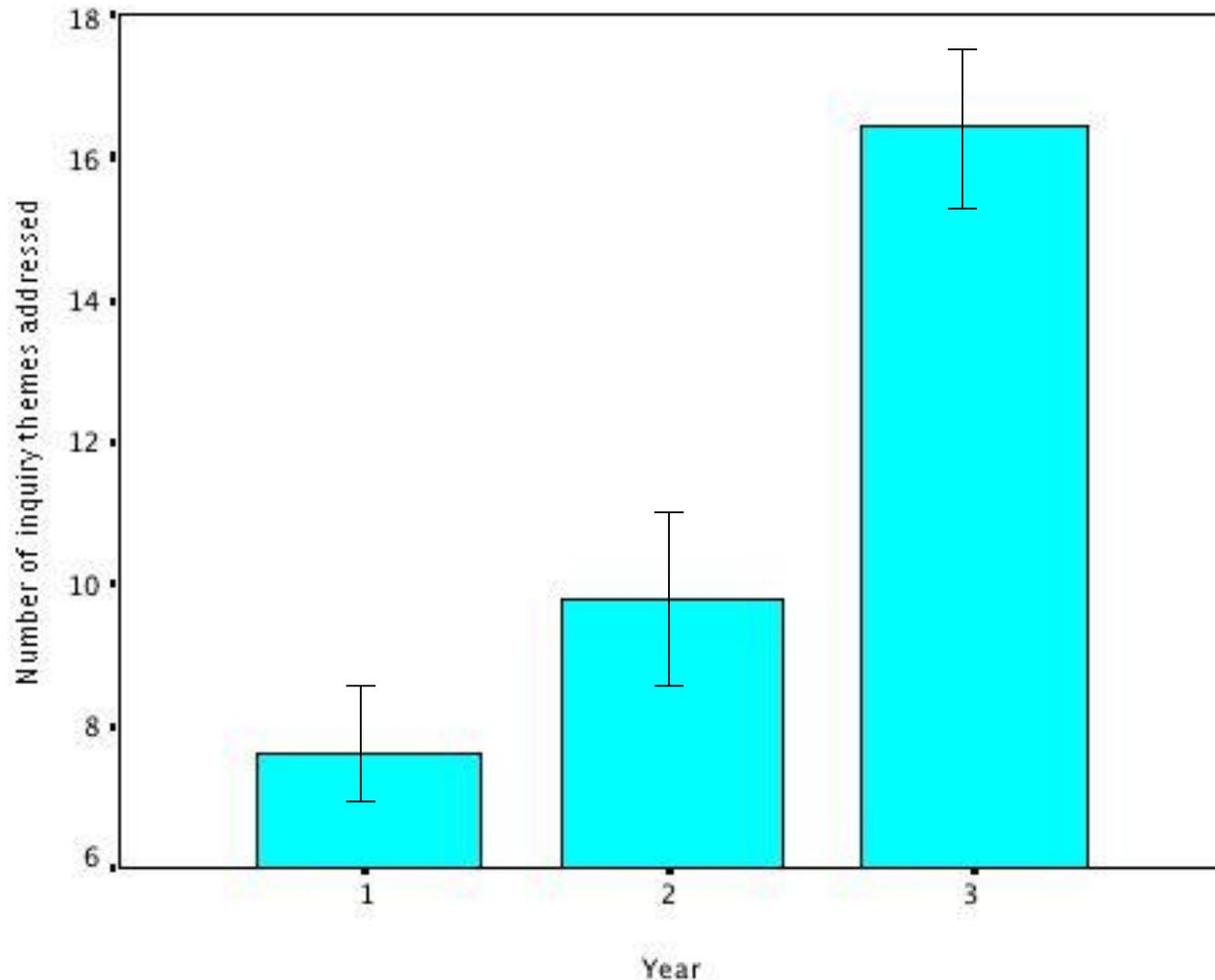
The teacher

Year 2: Interacting-group

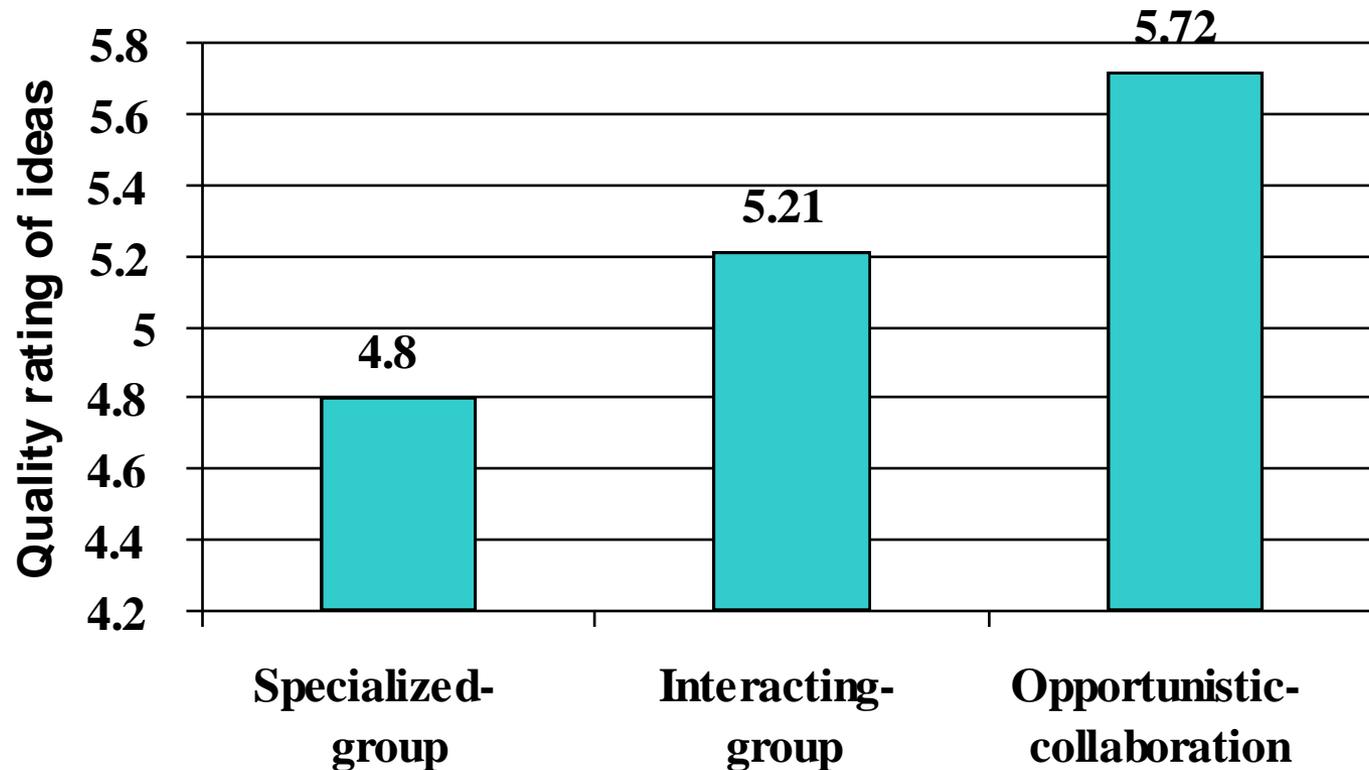
The teacher



Year 3: opportunistic-collaboration



Mean number of inquiry themes about which a student reported knowledge advances in his/her portfolio note ( $F(2, 63) = 64.14, p < .001$ ).



Student ideas were rated based on scientificness and depth/complexity. ( $F(2, 63) = 5.69, p < .01, \eta^2 = 0.15$ ).

# Approaches to Education for Innovation

## **Traditional Education**

Learn First; Innovate Later

Basics before “higher order” skills

## **Knowledge Building**

Innovation part and parcel of the enterprise from Day 1

# Theorizing in Kindergarten

- Class does traditional walk outside to observe signs of spring.
- Children notice trees on one side of the schoolyard are in leaf whereas similar trees on the other side are not.
- Teacher leads children to list facts that need explaining and to produce explanations of the facts.

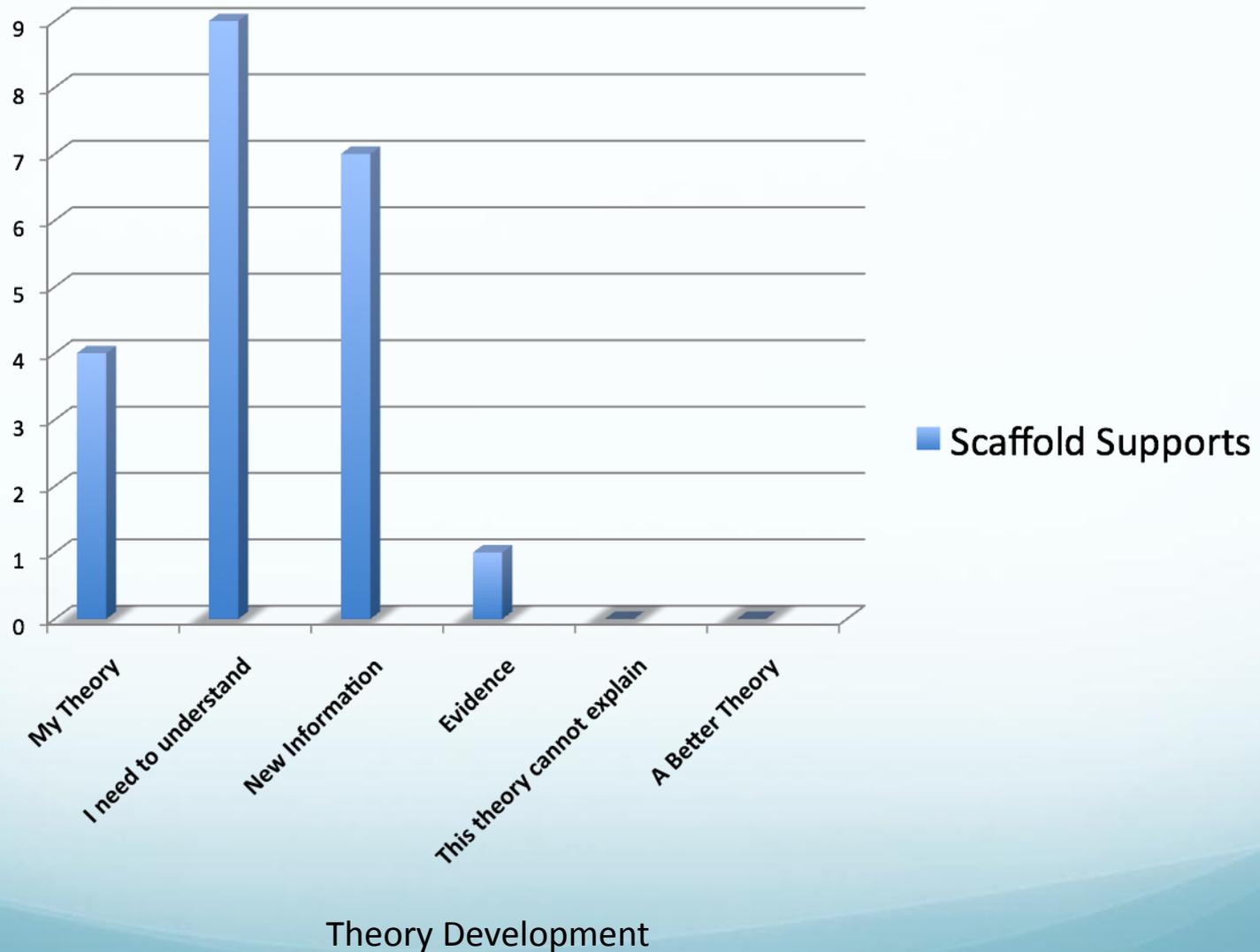
## Facts

- \* the trees in the wood chips next to the school were in blossom.
- \* the trees in the wood chips near the climbers were not in bloom
- \* the first trees had leaves and flower blossoms  
The second trees didn't have leaves or blossoms
- \* Spring is when things are supposed to blossom

## Explanations

- \* maybe the Sun was more facing to one bunch of trees
- \* maybe they are different kinds of trees
- \* maybe they are different ages
- \* maybe some of the trees got not as much sun or rain
- \* maybe some of the trees died in the winter
- \* maybe they were planted at different times
- \* sprinklers might not have worked

# Theory Development Beyond Grade Level



# The Simple Story

The more students work creatively with ideas  
the more they learn,  
the more they innovate

# **The Quickest way to a Knowledge Building Community**

Get students committed to improving their theories, in a community of students committed to advancing not only their own ideas but those of the community as a whole.

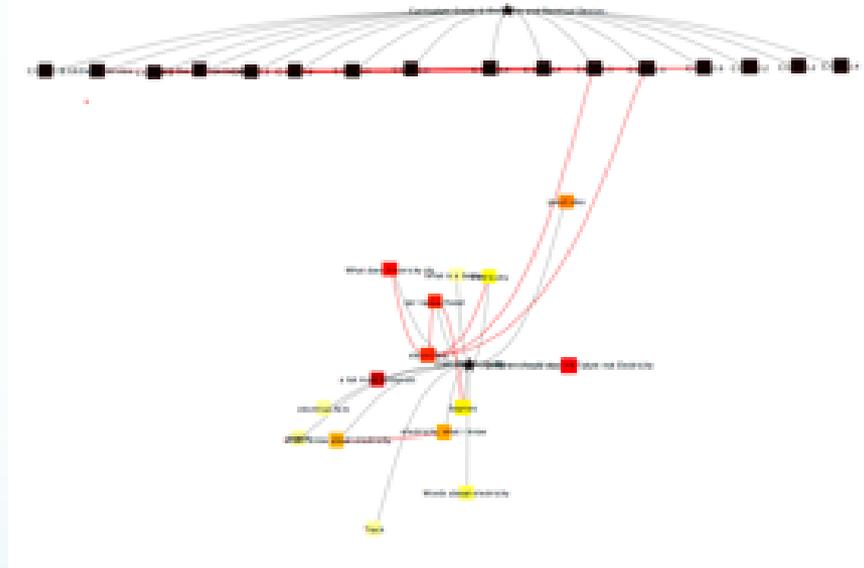
# The Quickest way to Sustaining Knowledge Building

Embedded, Transformative and Concurrent Assessment.

Communities committed to going beyond best practice

# Latent Semantic Analysis

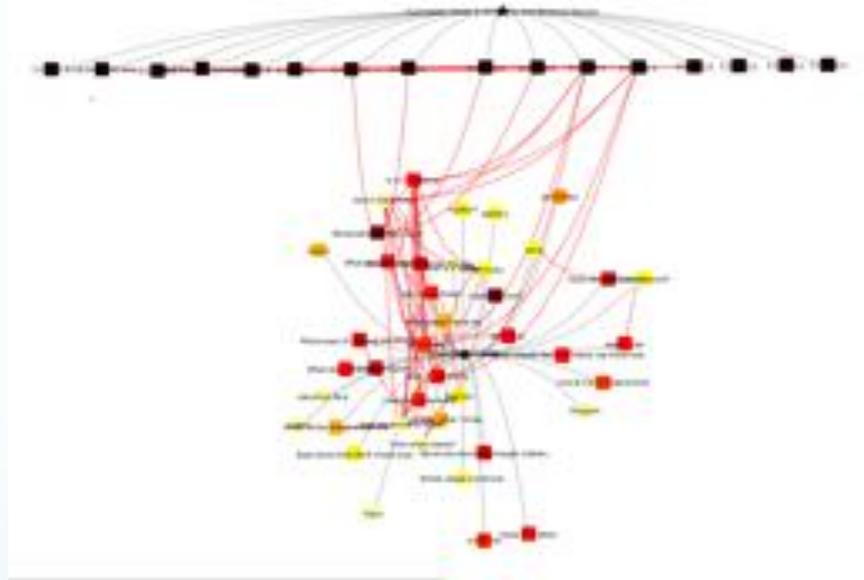
Benchmark--Expert Corpus



Student Discourse--Day 1

# Latent Semantic Analysis

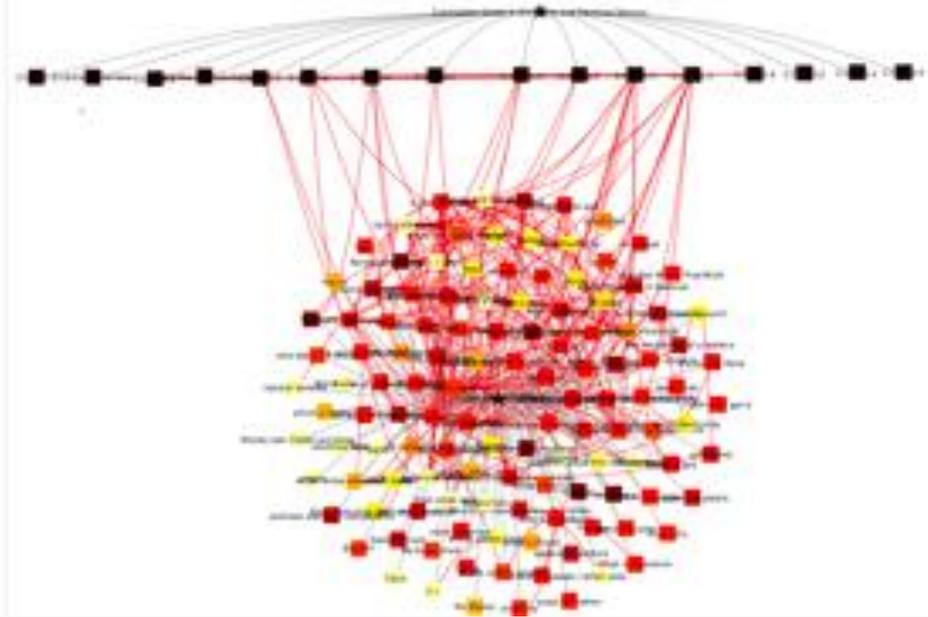
Benchmark--Expert Corpus



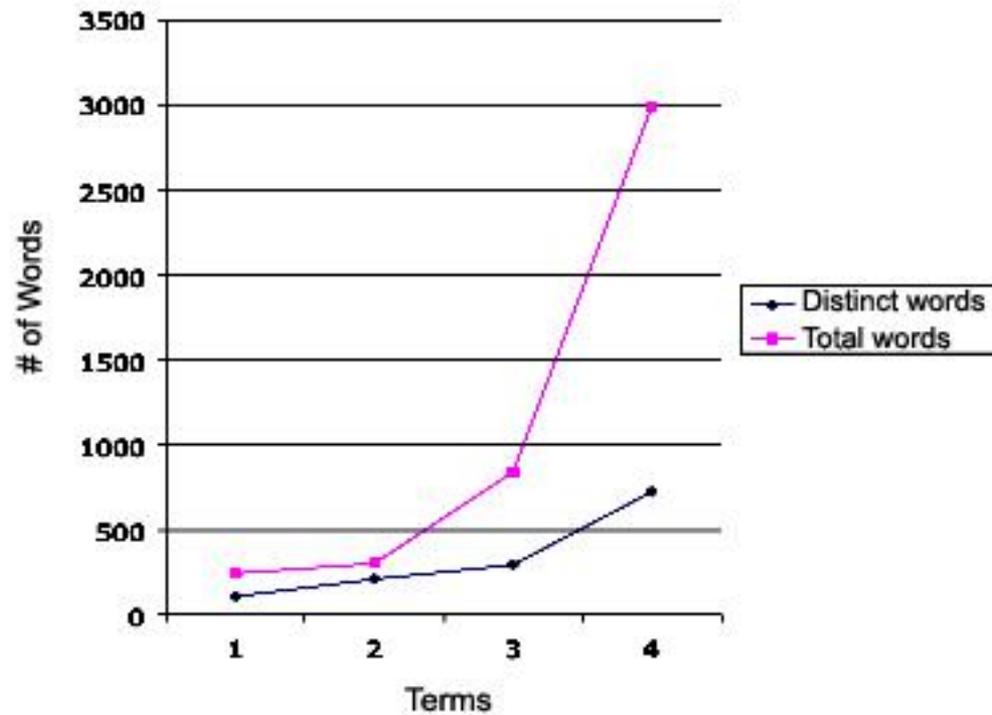
Student Discourse--Day 10

# Latent Semantic Analysis

Benchmark--Expert Corpus



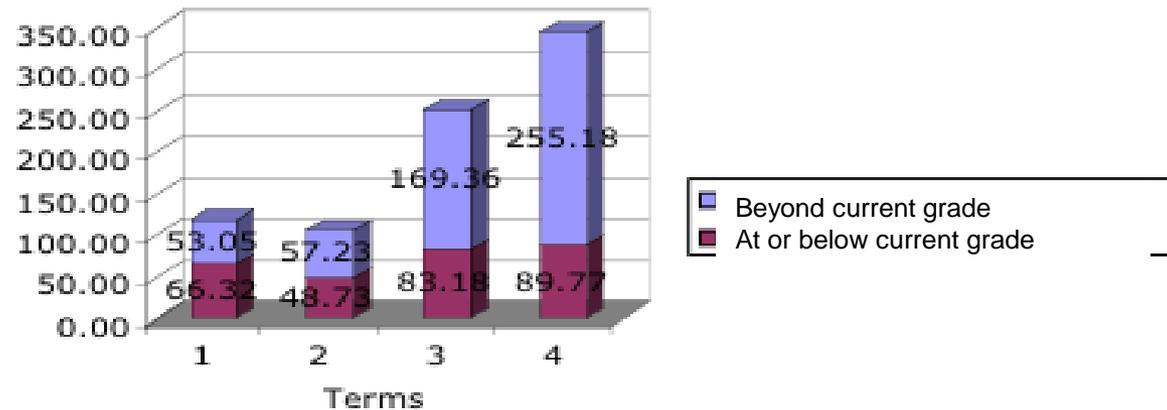
Student Discourse--Day 32



Total and distinct words--average per student over four semesters

# Vocabulary Beyond Grade Level

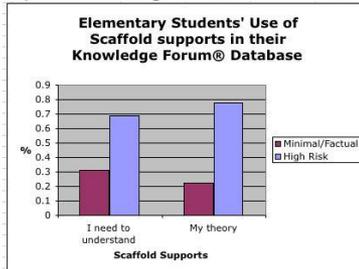
Number of new words per student over two years, four school terms



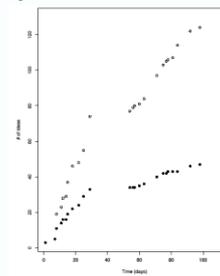
The number and grade level of new vocabulary (words not used earlier) per student notes.

# 21st Century Skills: Theory Development, Leadership, Risk Taking, New Ideas

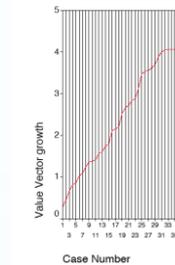
## Leadership, Risk Taking



## Idea Diversity

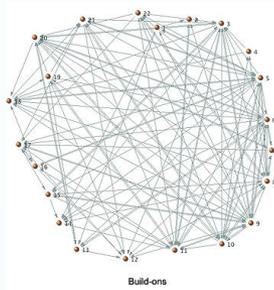


## New Ideas

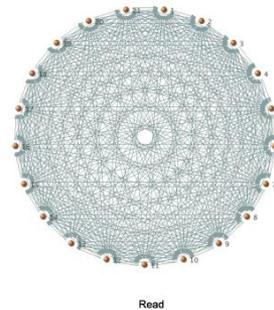


# Teamwork--Build On, Reading, Reference, Search

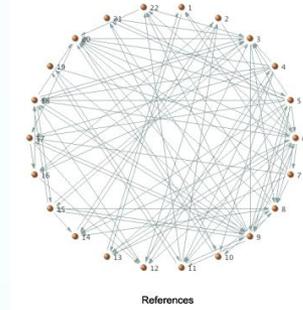
## Teamwork-Build On



## Teamwork-Read

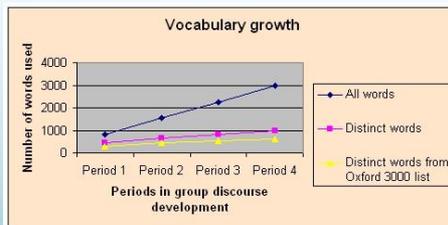


## Teamwork-Citations

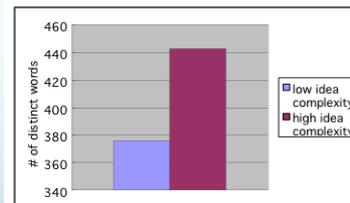


# Literacy--Writing, Vocabulary Growth

## Vocabulary Growth

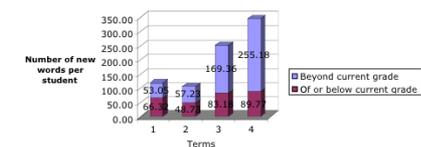


## Distinct Words



The # of **distinct words** in the notes of students showing lower and higher level of idea complexity ( $p=0.037$ )

## Vocabulary Beyond Grade Level



The number and grade levels of **new vocabularies (words that had not used in earlier term(s))** introduced in per student's notes in the four terms

# Practices that Minimize Work With Ideas

- Exam preparation
- Covering the curriculum
- Doing schoolwork
- Problems as exercises
- Activity-centered methods (games, projects, etc.)
- Overemphasis on facts
- Overemphasis on opinions
- Overemphasis on methods
- Overemphasis on skills
- Overemphasis on presentation

# Practices that Maximize Work With Ideas

- Formulating authentic problems
- Problem analysis
- Theorizing
- Criticizing and improving theories
- Designing and carrying out empirical tests of theories
- Identifying information needed for idea improvement
- Making connections among ideas
- “Rising above” competing ideas
- Assessing progress in knowledge building discourse