From Consumers to Producers: Promoting Transformational Literacy Instruction Through Science

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Driving questions

- What are the common cognitive strategies and behaviors that undergird scientific inquiry, science content acquisition, and literacy?
- How can instructional activities be designed to maximize on the synergy involved?
- How can these new activities be used to raise student achievement in both science and literacy?

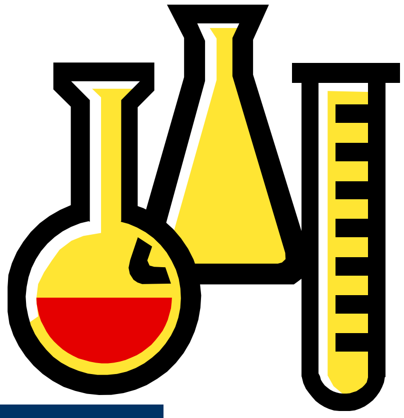
Norris & Phillips (2003, p. 224)

"literacy in its fundamental sense is fundamental to scientific literacy"

Re-examining the definition of inquiry

[Inquiry is] a multifaceted activity that involves making *observations*; posing *questions*; *examining* books and other sources of information to see what is already known; *planning* investigations; *reviewing* what is already known in light of experimental evidence; using tools to gather, *analyze,* and *interpret* data; *proposing* answers*, explanations,* and *predictions*; and *communicating* the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations [italics added to highlight specific cognitive processes] (NRC, 1996, p. 23).

Creating a “reverse” reaction



Traditional View:

- READ TO “LEARN” SCIENCE
- WRITE TO “LEARN” SCIENCE
- Emphasis on learning science through text experiences

VS.

New View:

- “DO” SCIENCE TO INCREASE LITERACY
- Emphasis on the interaction between inquiry & literacy cognition and transference of inquiry thought to literacy practices

Can you really use science to raise literacy?

Let's look at the findings . . .

30 years of historical findings on the interplay among science, reading, and writing

- Cognitive skills and logical abilities (such as those developed by science inquiry activities) are prerequisites for effective reading instruction (Furth, 1970).
- Children actively construct knowledge about reading and writing similar to their construction of knowledge about science (Ferreiro & Teberosky,1982).
- Primary students who participated in science process skill activities showed significant gains in reading readiness (Ayers, 1969) & reading comprehension compared to control (Morgan, Rachelson, & Lloyd, 1977).
- Grade 3 students exposed to science process skills or inquiry curriculum programs performed significantly better than control on measures of both science process ability & reading (Kolebas, 1971), and in reading comprehension, spelling, & language expression (Esler & Midgett, 1978).

Continued . . .

- Writing develops critical reasoning skills (Newell, 1998) and strengthens reading skills (see Langer & Applebee, 1987; Tierney et al., 1989).
- Writing can contribute uniquely to understanding content concepts if students engage in tasks that encourage them to explore the important understandings in a particular domain (Newell & Winograd, 1989).
- Writing explanations supports children’s reasoning about and understanding of science phenomena (Klein, 2000; Chi et al., 1989, 1994; Meyer & Woodruff, 1997), and has recently been demonstrated as effective with students as young as grade 4 (Chambliss, Christenson, & Parker, 2003).
- Reading and writing instruction is more meaningful when placed in a content area, such as science, than when performed as a general skills exercise lacking clear purpose (National Reading Panel, 2001; Block & Mangieri, 1997; Goldman, 1997).

Re-examining content area instructional practice

Current view of subjects and approach: linear model

- Literacy → Student Achievement
- Science → Student Achievement
- Mathematics → Student Achievement

Proposed synergistic model

Singular focus that yields synergistic outcomes

- Fundamental Inquiry Development

- Reading
- Writing
- Science
- Mathematics

Emphasizing inquiry as a tool for thought in all domains

Informed decision-making

Forming linkages between cognition, curriculum, instruction, and assessment

Cognition INFORMS the curricula of

- Reading
- Writing
- Science
- Mathematics

WHICH INFORM

Instruction and assessment of these subjects

Expected Outcomes

STUDENTS:

- Reflective
- Increased capacity in literacy and content
- Decision-maker
- Independent *and* Collaborative
- Self-regulatory – “directors” of their own learning

TEACHERS:

- Reflective
- Increased capacity in literacy and content
- Decision-maker
- Independent *and* Collaborative
- Changed in self-concept and professional identity

Thinking Like A Scientist

Exploring transferring inquiry skills to literacy with Kindergarten students

Project Overview

- Descriptive exploratory study
- SY 2004-2005
- 20 Kindergarten students in one class; teacher with Master's degree in Reading and 11 years experience
- 60% Anglo; 50% Hispanic; 5% African-American; 5% Asian; no LEP; no ESE
- Five researcher-delivered lessons (one per month) with teacher-led connections continuous throughout
- Each lesson connected inquiry activity to inquiry skill building, followed by explicit connections to literacy
- Used Science-Cognition-Literacy Framework for instructional design.

The Science-Cognition-Literacy Framework

(Miller, in press)

SCL Framework intentions

- To serve as a guide for putting together science and literacy in a seamless manner
- To treat reading and writing *not* as ancillary activities to support science learning, but to fully embed the literacy activities into the science curriculum and take on an equally important role to those of hands-on inquiry experiences.

Science inquiry skill	SCL Phase	Reading application to be taught to students
Prediction	Acquisition	❖ Before reading, students should preview the text and predict what the reading sample is about from the title, illustrations, and other key text components. ❖ As students read, students should constantly predict and anticipate what the next points to be discussed in text will be.
Observation	Acquisition, Internalization	❖ Students use their observation skills to take note of key points in text – headings, boldface terms, illustrations, special use of language. ❖ Students should use contextual clues from the reading to decode new vocabulary, observing where and how the new terms are used and what supporting vocabulary and ideas are used to extend their meaning.
Questioning	Acquisition, Internalization	❖ The K-W-L technique can be used before, during, and after reading to generate questions related to student knowledge. ❖ As they read, students should make margin notes and use the think-aloud strategy to sketch questions on the reading sample (or extra paper) to provide a concrete reminder of points that were not understood and need to be discussed in small groups or with the teacher. ❖ During the reflection activities, students must constantly self-assess their understanding of the reading, questioning themselves and posing questions to others as appropriate.
Planning	Acquisition	❖ When students preview the reading sample, they should examine the structure of the text (sequential, descriptive, compare/contrast, etc.) and select an appropriate graphic organizer or other organizing tool (such as a T-chart) to use while reading to organize the points of information in the text.
Reviewing, Analyzing, Interpreting data	Internalization	❖ After reading, students should review what they have read and revisit and revise their graphic organizers if necessary, reconstructing their ideas and incorporating their knowledge from the hands-on activities with what they have read.
Explaining, Communicating	Transformation	❖ Students should be required to explain, in a variety of forms and orally and in writing, what they have read. Doing so strengthens reading comprehension and science content knowledge.

Using the Predict – Observe – Explain Sequence with Reading

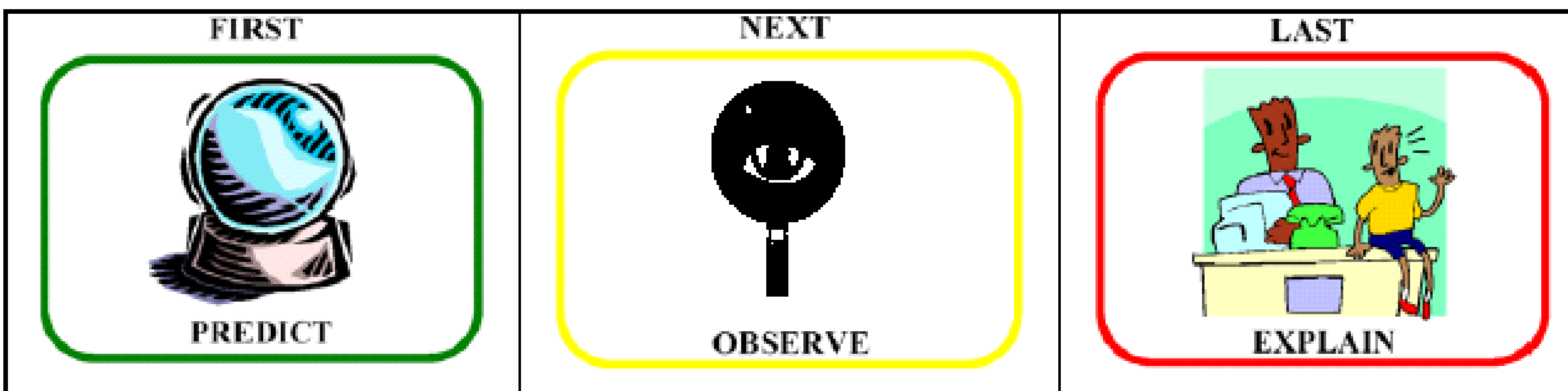
Making transferring inquiry skills to reading easy

When we read, we first predict what the passage will be about.

Next, while we read we observe not only what ideas are being presented, but how they are presented (vocabulary, structure, voice, etc.)

Last we explain what we have read to others, either orally or in writing.

This format builds upon the First-Next-Last sequence found in some publisher's materials and on Writer's Workshop sequencing of steps.



Anecdotal Results

- Students spent more time in previewing and selecting texts to read
- Greater sense of “power” [teacher quote] with how they viewed themselves as readers
- Able to explain scientific phenomena from activities with relative ease
- Less passive when reading
- Gave students a *process* to follow when they read or wrote (same finding as Kindergarten study)

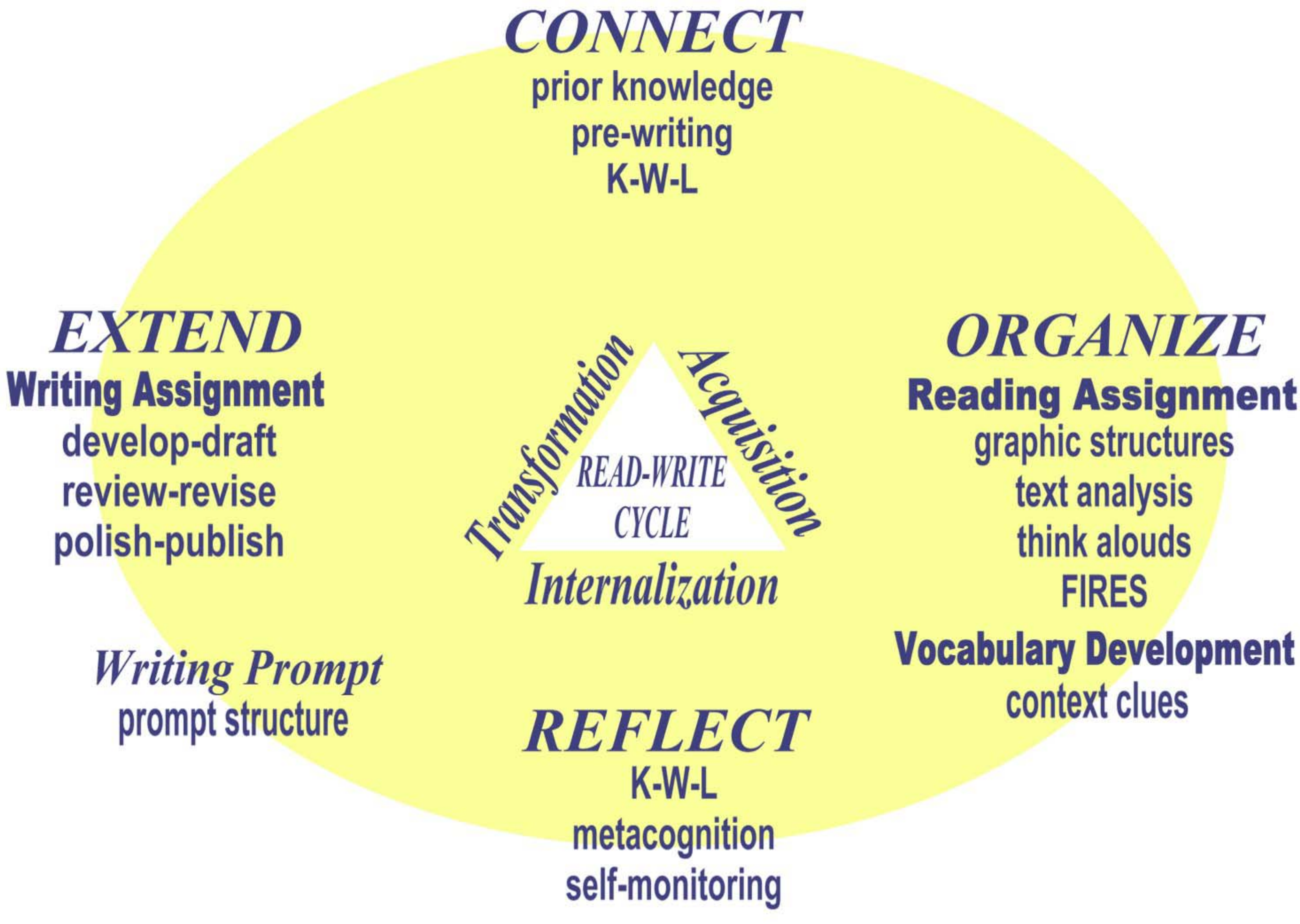
The Reading and Writing About Science Project

Exploring developing inquiry skills and science content in literacy settings with upper elementary students

Project Overview

- Formal design-experiment study; repeated measures over time
- SY 2001-2004
- 251 students; 21 teachers; 3 schools; 1 school per district
- 83% Hispanic; 12% African-American; 5% Anglo
- One-third of students LEP; over 80% low SES
- Students participated in prewrite assessment and two science units (approx. 4 weeks each) grounded in literacy experiences
- Student writing measured 2x per unit
- Used Read-Write Cycle for instructional design.

The Read-Write Cycle (Miller & Calfee, 2004).

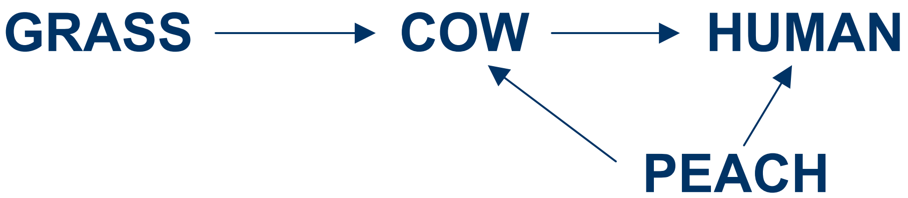


RW Cycle intentions

- To serve as a guide for putting together reading, writing, and content in a seamless manner
- To emphasize metacognition throughout all phases of instruction
- To provide a model that could be used across grades with a wide variety of students of varied linguistic and social backgrounds.

Sample Writing Prompt in FATPS Format (Grade 4; food webs)

In our work over the last week, you learned about producers, decomposers, and the different types of consumers. Think about this example of a food web:



Write as many paragraphs as you need to your teacher to explain what category describes each of the members of this food web and why. Are grass, cows, humans, and peaches consumers, producers, or decomposers? You figure it out! For any consumers you list, also tell what type they are: herbivore, carnivore, or omnivore. Be sure to explain your reasons for your choice of category and explain your ideas clearly and completely.

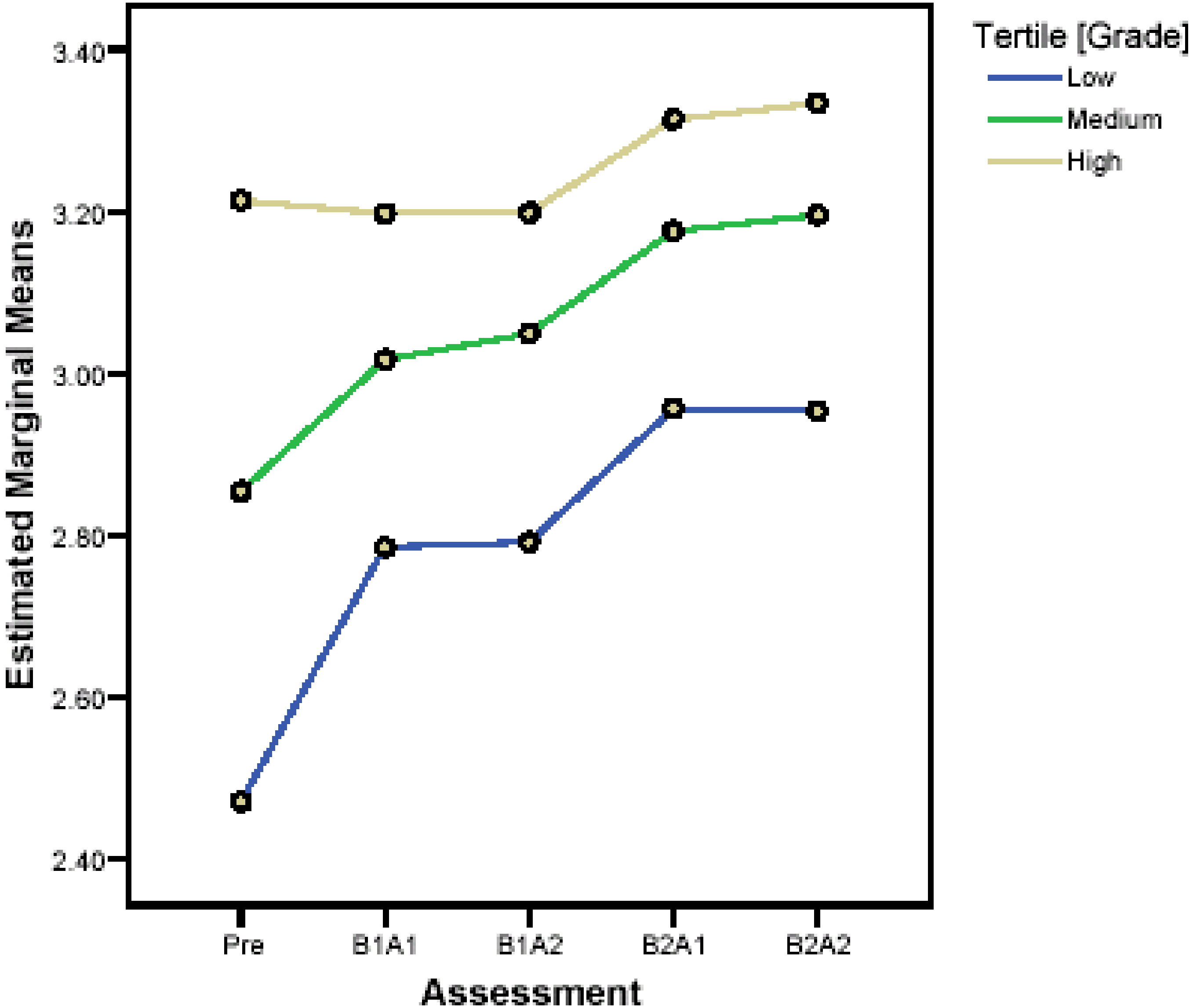
Sample Student

- From low SES school
- 83% minority population
- Grade 4
- Pre score on writing assessment less than 2 out of 5 points on the rubric scale
- Note acquisition of content vocabulary in writing

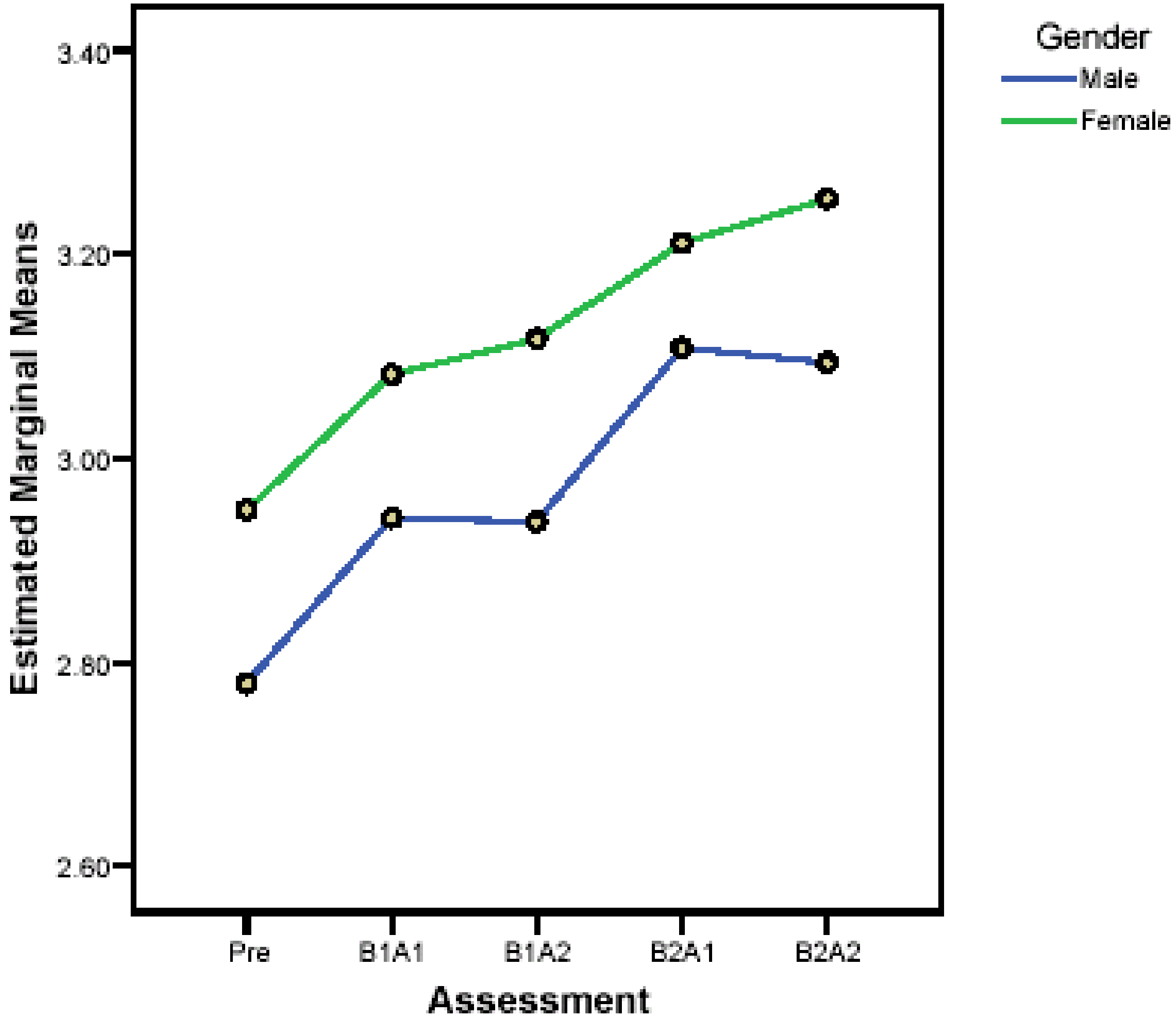
Grass in the food web is a producer. Producers are organisms who make their own food using sunlight or the sun's energy. Why I think that grass is a producer is because it is a plant that has chlorophyll or the green pigment found in plants, that captures the sun's energy to produce sugar or glucose in it.

The cow in the food web is a consumer. Consumers are organisms that eat other organisms. The type of consumer the cow is, is a herbivore. Herbivores are organisms that eat only plants. Why I think the cow is a herbivore is because it only eats the grass and peach on the food web.

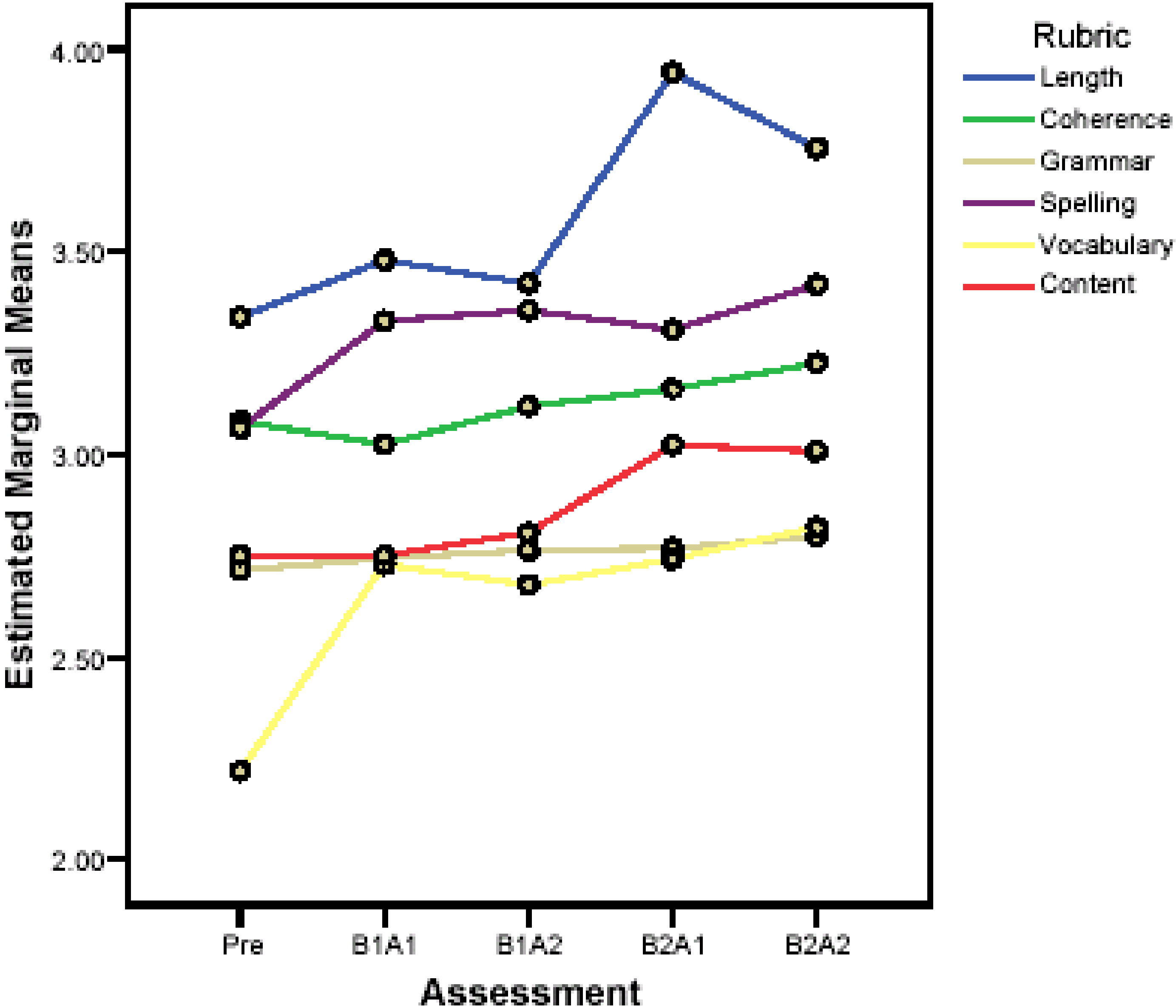
The human in the food web is a consumer. The type of consumer it is, is a omnivore. Omnivores eat both plants and animals. Why I think that the human on the food web is an omnivore is because it eats both the cow and the peach. The peach in the food web is a producer because it get it's energy from the sun.



Combined rubric means by tertile.



Combined rubric means by gender.



Means by rubric by assessment.

Key findings

- Substantial length increase
- Coherence increase despite more difficult topics
- Content increase demonstrates the interaction between reader and reading; greater richness to writing
- Greater student metacognition
- Greater student motivation
- Scaffolded *process* for reading and writing

Summary

By capitalizing on the interplay between science and literacy, we get an instrucitonal “two-fer”; more time to spend working on science and better student results in science, reading and writing at all grade levels.

Using a framework for these activities “charts the course,” yielding a process that students and teachers can follow, leading to metacognitive gains and increased motivation.