<u>A Short Study of Effective Science Instruction for ELL Junior Students</u>

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<u>Ontario Curriculum Directive:</u>

The Ontario Curriculum for the junior grades includes a Scientific Inquiry/Experimentation Skill Continuum. Although there is no single scientific method, there are scientific methodologies – practices that are followed when investigating questions in a scientific manner. In scientific inquiry, students engage in activities that allow them to develop knowledge and understanding of scientific ideas in much the same way as scientists would. Like scientists, students must also develop skills in the two major components of scientific inquiry – experimentation and research. Experimentation involves conducting "fair tests" to determine whether changing one factor in the experimental set-up affects the results, and, if so, in what ways. In a fair test, the scientist/student identifies variables that may affect the results of the experiment; selects one variable to be altered (tested), and keeps other variables constant; measures all trials in the same way; and repeats tests to determine the validity of the results.

<u>Context:</u>

This study was the result of classroom action-based research class in a mainstreamed class of 26; 6 students were special ed and 2 students were English Language Learners. Because it was a split grade, I had double the amount of science topics from which to choose. This study examined quality experiments for junior students and optimal strategies to teach math and science vocabulary and science text forms to present outcomes.

<u>Literature Review:</u>

Klahr, David; Nigam, Milena. "*The Equivalence of Learning Paths in Early Science Instruction: Effects of Direct Instruction and Discovery Learning*" Psychological Science October 2004 15: 661-667.

In a study with 112 third- and fourth-grade children, we measured the relative effectiveness of discovery learning and direct instruction at two points in the learning process: (a) during the initial acquisition of the basic cognitive objective (a procedure for designing and interpreting simple, unconfounded experiments) and (b) during the subsequent transfer and application of this basic skill to more diffuse and authentic reasoning associated with the evaluation of science-fair posters. We found not only that many more children learned from direct instruction than from discovery learning, but also that when asked to make broader, richer scientific judgments, the many children who learned about experimental design from direct instruction performed as well as those few children who discovered the method on their own. These results challenge predictions derived from the presumed superiority of discovery approaches in teaching young children basic procedures for early scientific investigations.

Pearson, David; Moje, Elizabeth and Greenleaf, Cynthia. "*Literacy and Science; Each in the Service of the Other.*" S*cience* 23 April 2010: Vol. 328 no. 5977 pp. 459-463.

This study examines the interplay between inquiry science and literacy teaching and learning of K-12 curriculum. It addresses two questions: i) how can reading and writing be used as tools to support inquiry-based science, and ii) how do reading and writing benefit when embedded in an inquiry-based science setting? After elaborating the theoretical and empirical support for integrated approaches, we discuss how to support their implementation in today's complicated curricular landscape.

Keys, Carolyn; Bryan, Lynn. "*Co-constructing inquiry-based science with teachers: Essential research for lasting reform.*" (July 2001) Journal of Research in Science Teaching

Volume 38, Issue 6, pages 631–645.

In this article Keys and Bryan assert a potential research agenda for the teaching and learning of science as inquiry as part of the JRST series on reform in science education. Drawing on the theoretical frameworks of cognitive and sociocultural constructivism, cultural models of meaning, the dialogic function of language, and transformational models of teacher education, we propose that more research is needed in the areas of teachers' beliefs, knowledge, and practices of inquiry-based science, as well as, student learning. Because the efficacy of reform efforts rest largely with teachers, their voices need to be included in the design and implementation of inquiry-based curriculum. As we review the literature and pose future research questions, we propose that particular attention be paid to research on inquiry in diverse classrooms, and to modes of inquiry-based instruction that are designed by teachers.

Beatrice Gibbons' 2003 "*Supporting Elementary Science Education for English Learners: A Constructivist Evaluation Instrument,*" The Journal of Educational Research Volume 96, Issue 6.

The author developed an evaluation instrument for elementary school administrators to promote constructivist teaching of elementary science for English learners. Classroom observations were conducted in 5th-grade classrooms of Hispanic and Filipino English learners in a multicultural school district in the Southern San Joaquin Valley of California. The repeated use of the instrument within the clinical supervision model resulted in increased frequency of ELD/SDAIE (English language development/specially designed academic instruction in English) methods and constructivist strategies in the elementary science classroom.

Hudson Shihusa and Fred N. Keraro "*Using Advance Organizers to Enhance Students' Motivation in Learning Biology*" Eurasia Journal of Mathematics, Science & Technology Education, 2009, 5(4), 413-420.

This study investigated the effect of using advance organizers on students' motivation to learn biology. The research design used was quasi-experimental design where the nonrandomised Solomon Four group was adopted. The focus was on the topic pollution. The sample comprised of 166 form three (third grade in the secondary school cycle) students in Bureti District, Kenya. Data was collected by using Students' Motivation Questionnaire (SMQ). A t-test, one-way ANOVA and ANCOVA statistical techniques were used to analyze the data. The findings indicate that students taught using advance organizers had a higher level of motivation than those taught using conventional teaching methods. The findings further indicate that following the intervention, male students had a significantly higher level of motivation than their female counterparts. This paper concludes by discussing the implications of these findings on current practice.

<u>Procedures</u>

<u>Recalls:</u> The students were given test booklets containing a science question.. Immediately after reading each passage, the students were asked to use a chart, diagram, list, table, equation and write down as much information as they could from the science problem. The students were also encouraged to use complete sentences, and to use the words in the passage or their own words, *see table 9*.

<u>Awareness Measures</u>: Two measures were taken of participants' awareness of science experiment text structure. The first, and most widely used measure was an assessment of organization used in the science report recall. In the second task, demanding greater metacognitive awareness of text structure, grade 4 and 5 students were asked to respond to an open-ended question asking, "What plan did the writer use?" For the purposes of making the task more concrete I added the sentences: "Circle the vocabulary words you remember. Tell me what kind of information was used." Students circled the vocabulary choices from from a multiple choice list.

Scoring and Reliabilities, Data Analysis:

Quantity and Quality of Idea Units Recalled: Each passage was analyzed into a set of idea units. Each idea unit consisted of a single idea. These were determined to be a top, high, mid or low level idea unit, according to the following criteria:

A1. Top-level: represents complete student summary of science report phrase.
A2. High-level: represents 80% student recall of science report phrase.
A3. Mid-level: represents 60-70% student recall of science report phrase.
A4 Low-level: represents less than 60% student recall of science report phrase.

I taught 26 grade 4 and 5 students science for 2 periods each day when a science unit was on the schedule. One of my main tasks as a classroom science teacher was to support students in their science vocabulary development and assist them in organizing their written answers to science questions using a variety of graphic organizers and linguistic cues as a support.

Metacognitive Awareness of Text Forms and Language

The second score for student metacognitive awareness was given for whether or not a student could accurately name the text form and science vocabulary of the passage. Presented with a chart, students circled the connective words they most frequently read and recalled in the test passage from a menu of vocabulary words for 4 informational text forms that were studied in class. They then underlined the text form term most often associated with that vocabulary.

Assessment

Over the past 10 years, much progress has been made in developing, implementing, and refining strategies and techniques that effectively integrate language and content instruction. However, the issue of assessment is still being resolved. Neither traditional language tests nor content achievement tests are adequate. However, broad-scaled mathematical data does yield findings which can tell us more about how to program effectively for junior students.

Large Scale Data Analysis

In 2011 there were 15 grade 5 students in a split grade. My study concluded with data from the EQAO scores for grade 5 students who took the EQAO test in 2012 with grade 6 students in other classes in school. The test required procedural text forms and content vocabulary for the reading, writing and math portions of the test.

Figure 1. Reading, Writing and Math Profile : EQAO Grade 6, 2012

Level 1 -numeracy skills are limited -reading and writing skills are limited	Level 2 -numeracy skills are emerging -reading and writing are emerging	Level 3 -numeracy skills are developing at standard -reading and writing skills are developing at standard	Level 4 -numeracy skills are developing toward proficiency toward proficiency -reading and writing are developing toward proficiency
1/38 Math	*1/37 Reading* *3/37 Writing* *8/38 Math*	*26/37 Reading* *20/37 Writing* *18/38 Math*	*10/37 Reading* *14/37 Writing* *11/38 Math*

Summary of Findings

The largest percentage of students were able to perform on the informational reading, writing and math section of the EQAO at provincial standard. No student fell into the bottom category for Vocabulary acquisition by the second teaching cycle. Over half of the students were able to score in the mid to high categories for the science recall by the second teaching cycle. Students improved over time in acquiring reading, writing and numeracy skills from 2009 to 2012, *see tables 7 and 8.*

Implications

A science curriculum that emphasizes direct instruction of science text form and science vocabulary, supported by technology and combined with graphic organizers to show science information builds confidence in elementary school-aged students who are acquiring science English.

Table 1. Vocabulary for Math in Science Units (4/ 5)

Number Sense and Numeration	*Measurement*	*Geometry and Spatial Sense*	*Patterning and Algebra*	*Data Management and Probability*
http://www.tvdsb.ca/webpages/mcauslanb/files/ns%20&%20nueration%20vocab%20t1.pdf	http://knowledgeloom.org/adlit/resources/CollabMathLessonMeasurement_Burnell.pdf	http://www.rda.aps.edu/mathtaskbank/pdfs/strands/str_gssm.pdf	http://www.ru.ac.za/media/rhodesuniversity/content/sanc/documents/CAPS_PATTERNS_30Aug2011.pdf	http://sci.tamucc.edu/~eyoung/1351/prob_vocabulary.html http://www.tvdsb.ca/webpages/mcauslanb/files/data%20management%20vocabulary.pdf
problem solving • reasoning and proving	problem solving • reflecting	problem solving • selecting tools/ computational strategies	problem solving • connecting • representing	problem solving • communicating

Table 2 Vocabulary for Combined Science Units (4/5)

Human Organ Systems/4 Habitat and communities 5	*Pulleys and Gears/4 Forces Acting on Structures and Mechanisms 5*	*Rocks and Minerals/4 Conservation of Energy and Resources 5*	*Light and Sound/ 4*	*and Properties of and Changes in Matter 5*
http://teachingrocks.ca/wp-content/uploads/2012/09/complete-4-5-life-sciences-unit-preview.pdf	http://teachingrocks.ca/wp-content/uploads/2013/01/Demo-Gr-45-Science-Unit-Pulleys-and-Gears.pdf	http://www.rocksandminerals4u.com/support-files/rocks-and-minerals-e-book.pdf http://orgs.educ.queensu.ca/curr/ElecCon.pdf	http://schoolmediainteractive.com/objct/tg/S1807TG.pdf	http://www.chagrinschools.org/Downloads/Sound%20and%20Light%20Vocabulary%20Key.pdf
problem solving • reasoning and proving	problem solving • reflecting	problem solving • selecting tools/ computational strategies	problem solving • connecting • representing	problem solving • communicating

Table 3. Results of Student Science Recall--first teaching cycle

Top 3/26	High 4/26	Mid 11/26	Low 8/26
-the student sample contained all main ideas and all related details.	-major ideas and details were recalled and written.	-some ideas and details were recalled and written.	-few details in the passage were recalled and written

Table 4. Results of Student Science Recall--second teaching cycle

Top 5/26	High 6/28	Mid 14/28	Low 3/28
-the student sample contained all main ideas and all related details.	-major ideas and details were recalled and written.	-some ideas and details were recalled and written.	-few details in the passage were recalled and written

Table 5. Results of Science Vocabulary Awareness-First Teaching Cycle

top 5/28	high 10/28	mid 10/28	low 3/28
-student sample was over 90% accurate	-student sample was over 80% accurate	-student sample was 60- 70% accurate	-student was less than 60% accurate

Table 6. Results of Science Vocabulary Awareness-Second Teaching Cycle

top 20/28	high 2/28	mid 4/28	low 0/28
-student sample was over 90% accurate	-student sample was over 80% accurate	-student sample was 60- 70% accurate	-student was less than 60% accurate

Table 7.Profile Student Reading, Writing, Math Scores for 2009 EQAO Grade 3,

Level 1	Level 2	Level 3	Level 4
	4/20 Reading *5/20 Writing* *6/20 Math*	*11/20 Reading* *11/29 Writing* *8/20 Math*	*2/20 Math*

Table 8.Profile Student Reading, Writing, Math Scores for 2012 EQAO Grade 6,

Level 1	Level 2	Level 3	Level 4
1/38 Math	*1/37 Reading* *3/37 Writing* *8/38 Math*	*26/37 Reading* *20/37 Writing* *18/38 Math*	*10/37 Reading* *14/37 Writing* *11/38 Math*

Table 9. Science/Math Question Recall #1:

Question: *What were the results of our last math test? How many students passed with a grade of 70 or higher? What do you conclude from this result?*	
First, I read the science/math question.	
Second, I underlined key words.	
Third, I listed materials.	
Next, I selected a diagram, chart, table, equation to help me picture and answer the question. (circle choice/s)	
After that, I performed the math procedures--adding, subtracting, division, multiplication--(check each procedure used)	
Then, I wrote the conclusion.	
Finally, I re-checked the conclusion.	

Student Sample:

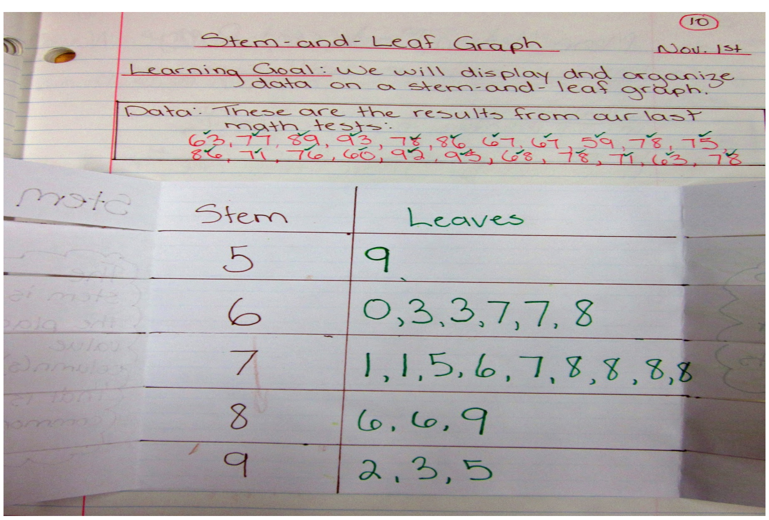

Table 10 Vocabulary and Science Report Text Form Awareness:

Vocabulary/Text Form for Informational Text

How to Books (Recount and Procedure) first, then, next, after, finally For example: Describe the habitat and life cycle of a butterfly	Same and Different Chart: (compare and contrast) the same as, different than, and, or What difference does insulation make to the temperature inside a metal container over time?
Reports (Descriptive) in, out, beside, above, below, next to, in front, behind Pulleys and Gears/Forces Acting upon Structures	Opinion Letters (Persuasion) agree, disagree, for example, proof, a reason, in conclusion What could the city do to conserve energy? Write a letter to the mayor.

Table 11. Science/Math Vocabulary/Symbols/Charts:

Addition	**Subtraction**	**Multiplication**	**Division**
sum, total, in all, increased by, combined, plus, more than	difference, how much more, exceed, decreased, take away	product, total, area, times, factor, twice, triple	share, distribute, quotient, average,divide, into, split up, break apart
+	**-**	**x**	**÷**

Equal	**Smaller**	**Greater**	**Unequal**
equal to, the same value, is, total, result, same as	of smaller value than/ **a** is lesser value or equal to **b**	of greater value than/ **a** is greater value or equal to **b**	not equal
=	2< 4 a ≤ b	4 > 2 a ≥ b	a ≠ b

Times Table - 12x12

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	**1**	2	3	4	5	6	7	8	9	10	11	12
2	2	**4**	6	8	10	12	14	16	18	20	22	24
3	3	6	**9**	12	15	18	21	24	27	30	33	36
4	4	8	12	**16**	20	24	28	32	36	40	44	48
5	5	10	15	20	**25**	30	35	40	45	50	55	60
6	6	12	18	24	30	**36**	42	48	54	60	66	72
7	7	14	21	28	35	42	**49**	56	63	70	77	84
8	8	16	24	32	40	48	56	**64**	72	80	88	96
9	9	18	27	36	45	54	63	72	**81**	90	99	108
10	10	20	30	40	50	60	70	80	90	**100**	110	120
11	11	22	33	44	55	66	77	88	99	110	**121**	132
12	12	24	36	48	60	72	84	96	108	120	132	**144**

Length	Weight	Volume
1 km = 1,000 m	1 kg = 1,000 g	1 kL = 1,000 L
1 m = .001 km	1 g = .001 kg	1 L = .001 kL
1 m = 100 cm	1 g = 100 cg	1 L = 100 cL
1 cm = .01 m	1 cg = .01 g	1 cL = .01 L
1 m = 1,000 mm	1 g = 1,000 mg	1 L = 1,000 mL
1 mm = .001 m	1 mg = .001 g	1 mL = .001 L

TIME

1 year = 365 days
1 year = 12 months
1 year = 52 weeks
1 week = 7 days
1 day = 24 hours
1 hour = 60 minutes
1 minute = 60 seconds

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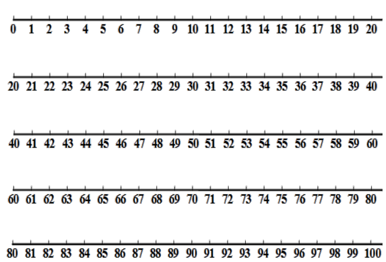


Prefix	Meaning	Length	Mass	Capacity
kilo-	thousand (1,000)	*kilo*meter	*kilo*gram	*kilo*liter
hecto-	hundred (100)	*hecto*meter	*hecto*gram	*hecto*liter
deka-	ten (10)	*deka*meter	*deka*gram	*deka*liter
*base unit	ones (1)	meter	gram	liter
deci-	tenths (0.1)	*deci*meter	*deci*gram	*deci*liter
centi-	hundredths (0.01)	*centi*meter	*centi*gram	*centi*liter
milli-	thousandths (0.001)	*milli*meter	*milli*gram	*milli*liter

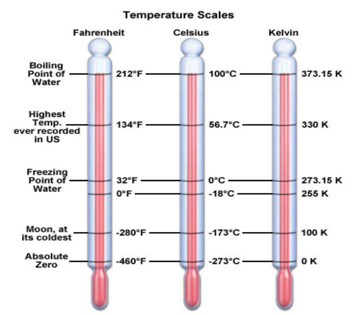
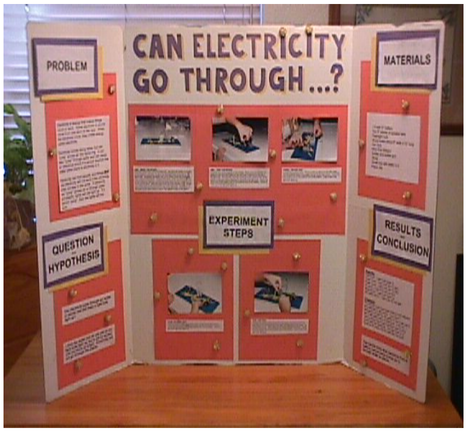
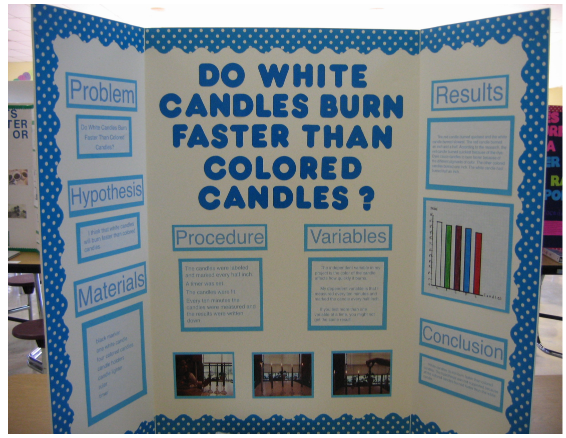
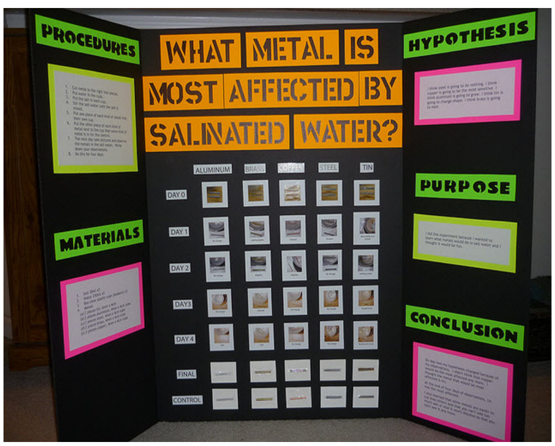
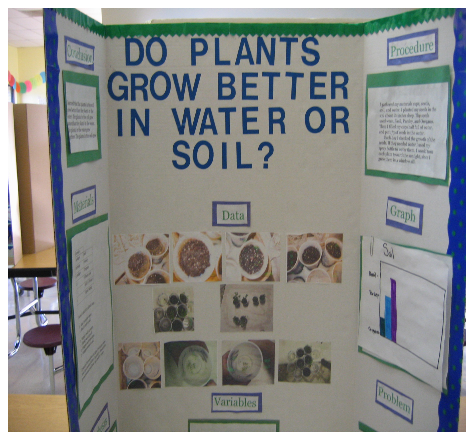


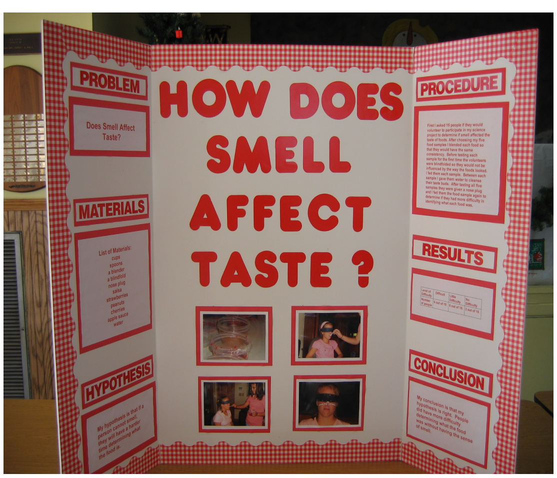
Table 12 Sample Junior Science Projects

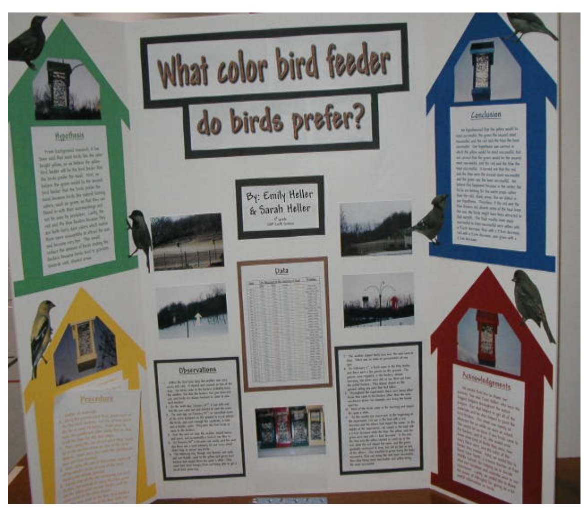












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