



Inquiry, Argument, & Representation: How Using Questions, Claims, and Evidence Improves Critical Thinking Skills and Science Understanding

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INTRODUCTION

Low achieving students, including those with mild and moderate cognitive disabilities have traditionally fared poorly in science achievement. Further, those same students have been shown to have difficulties with the process of thinking critically. As the future job market becomes more technical, the need for basic science knowledge and critical thinking skills becomes paramount, especially for students who traditionally lag behind.

The use of inquiry-based, hands-on instruction has shown evidence of improving outcomes for students that are considered low achieving. The Science Writing Heuristic (SWH) is an argument-based inquiry approach to teaching and learning science. The SWH approach is designed to involve students in inquiry, argumentation, and experimentation as a means of learning science and improving critical thinking skills. For low achieving students, exposure to the SWH has shown to be promising in those target areas.

SWH & LOW ACHIEVING STUDENTS

The Science Writing Heuristic (SWH) includes a number of components that science educators consider important for students to learn science in general. The SWH also provides elements of instruction that can be considered essentials for students that are low achieving to improve science learning. These elements include:

- Focus on Big Ideas
 - Using conceptual frameworks
 - Connecting prior knowledge to new information
 - Hands-On experimentation
- Use of Visual Supports
 - Concept maps
 - Multimodal representation
 - Graphic organizers
- Peer-Assisted Learning
 - Pairs
 - Small groups
 - Whole class
- Student Empowerment
 - Embedded use of negotiation/argumentation
 - Value of student ideas

METHODS

Participants

- Rural Midwest School District
 - Achievement (*Iowa Test of Basic Skills*)
 - 2009 – 2010 School Year
 - Grades 6 – 8 (Gen Ed, IEP, SES, SES/IEP)
 - Science Proficiency vs. Reading & Math
 - Proficiency Differences (Reading / Science; Math / Science)
 - Critical Thinking (*Cornell Critical Thinking Test*)
 - 2008 – 2010
 - Grades 5 & 6
 - Low Achieving Treatment vs Low Achieving Control

Procedure

- Teachers were trained to use the SWH approach and provided support through professional development and feedback

RESULTS

ACHIEVEMENT

ITBS Subscale Proficiency Scores

	Reading	Math	Science
8 th Grade Gen Ed	78	87	91
8 th Grade IEP	26	48	70
8 th Grade SES	70	81	88
8 th Grade SES/IEP	60	75	76
7 th Grade Gen Ed	82	73	90
7 th Grade IEP	29	31	63
7 th Grade SES	69	65	84
7 th Grade SES/IEP	22	55	76
6 th Grade Gen Ed	70	80	93
6 th Grade IEP	19	38	62
6 th Grade SES	65	73	85
6 th Grade SES/IEP	54	63	78

ITBS Subscale Proficiency Differences

	Science / Reading % Difference	Science / Math % Difference
8 th Grade Gen Ed	▲13	▲4
8 th Grade IEP	▲44	▲22
8 th Grade SES	▲18	▲7
8 th Grade SES/IEP	▲16	▲1
7 th Grade Gen Ed	▲8	▲17
7 th Grade IEP	▲34	▲33
7 th Grade SES	▲15	▲19
7 th Grade SES/IEP	▲54	▲21
6 th Grade Gen Ed	▲25	▲14
6 th Grade IEP	▲43	▲26
6 th Grade SES	▲20	▲12
6 th Grade SES/IEP	▲24	▲15

RESULTS

CRITICAL THINKING

Means & Standard Deviations

Variables	Pre-Test		Post-Test		t-score	df	p
	M	SD	M	SD			
CCT – Total							
LA-Treatment	33.71	6.567	38.17	7.172	-5.936	117	.000
LA-Control	36.91	7.785	37.7	7.26	-0.995	89	.323
CCT – Induction							
LA-Treatment	12.53	3.978	14	3.496	-3.652	117	.000
LA-Control	12.91	3.732	13.88	3.578	-2.158	89	.034
CCT – Deduction							
LA-Treatment	8.89	2.908	10.94	3.332	-5.579	117	.000
LA-Control	10.72	4.114	10.63	3.354	0.196	89	.845
CCT – Observation							
LA-Treatment	9.08	3.053	10.08	3.118	-2.729	117	.007
LA-Control	9.94	2.497	9.82	2.676	0.367	89	.714
CCT – Assumption							
LA-Treatment	2.79	1.716	3.51	1.518	-3.499	117	.001
LA-Control	3.57	1.855	3.61	1.541	-0.176	89	.861

Effect Sizes Comparisons

	Cohen's d	95% CI		Hedge's g	95% CI	
		Lower	Upper		Lower	Upper
Total						
LA-Treatment	.651	-1.525	0.222	.647	-1.524	0.231
LA-Control	.108	-0.769	0.554	.107	-0.770	0.556
Induction						
LA-Treatment	.394	-0.870	0.082	.391	-0.869	0.086
LA-Control	.267	-0.798	0.264	.264	-0.798	0.270
Deduction						
LA-Treatment	.658	-1.056	-0.261	.653	-1.052	-0.254
LA-Control	.024	-0.521	0.569	.024	-0.524	0.572
Observation						
LA-Treatment	.325	-0.717	0.067	.323	-0.717	0.071
LA-Control	.047	-0.329	0.423	.046	-0.332	0.424
Assumption						
LA-Treatment	.446	-0.652	-0.241	.443	-0.650	-0.236
LA-Control	.024	-0.271	0.224	.023	-0.272	0.226

Note. CI = confidence intervals, LA = low achieving, HA = high achieving;

DISCUSSION

- Overall, all students including those considered low achieving (IEP & SES) showed marked difference in science than reading and math achievement
- Compared to other low achieving students, those in SWH classrooms performed significantly better on critical thinking measures
- SWH classrooms were more effective in improving critical thinking skills for Low Achieving students than traditional classrooms