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ABSTRACT

The goal of this research was to determine the effectiveness of a middle school science curriculum designed to inspire students to think about science through studying the patterns of humans. The curriculum focuses on human behavior, evolution, ecology, and performance and is based on the notion that pattern recognition is highly correlated with the ability to succeed in school type learning tasks. The effectiveness of the curriculum was determined by using an instrument developed to measure the self-efficacy of young adolescents to recognize patterns in the natural world. Results show that the ability to recognize patterns does not seem to be equal in all learners and is a skill that can be improved through training. The research results also indicated an unexpected difference in pattern recognition between genders and suggests that relating science to people patterns could contribute to encouraging higher female interest in science. The historical significance of patterns and their recognition in science is also discussed. (DDR)

Self-efficacy of Pattern Recognition in Science of Middle School Students

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Abstract

Over the history of science, recognition of patterns has lead to discovery. What often separates scientists from nonscientists is the ability to recognize patterns that no one else sees. Pattern recognition is highly correlated with the ability to succeed in school type learning tasks. However, the ability to recognize patterns does not seem to be equal in all learners. The skill of pattern recognition can be improved through training.

A curriculum was developed to inspire middle school students to think about science concepts through studying patterns of humans (behavior, evolution, ecology, performance). The effectiveness of this curriculum was determined by using an instrument developed to measure the self-efficacy of young adolescents to recognize patterns in the natural world. After using the curriculum for an academic year, middle school students got more confident at the discovery skills dealing with people and numbers.

Self-efficacy of Pattern Recognition in Science of Middle School Students

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Introduction

The ideal way to teach is to present information in such a way that the brain has to extract patterns, rather than have them imposed upon it (Caine and Caine, 1994). The call for curricular reform for teaching both math and science recommends that patterns of the natural world be used as a starting place to inspire thinking about math and science concepts (Massachusetts Curriculum Frameworks for Science and Math, 1995). We discovered through working with a number of youngsters that the skill of pattern recognition is not equal in all students. While some youngsters could recognize a pattern instantly, many youngsters needed coaching. Because discovering patterns is the work of science, games and activities were developed over a period of several years to enhance pattern recognition in all students. While anecdotal evidence suggested that the pedagogy and curriculum to enhance pattern skills worked, there was no scientific evidence to prove it. This led to the present research effort around the question, "can the skill of pattern recognition be improved through training?." Encouraged by reports that pattern skills are linked to success in schools, middle school students were chosen as subjects for the study and their teachers were trained to lead them in skill development.

This study grew out of an experience leading a summer science program for middle school youngsters on the campus of Springfield College. Called Real World Science (Barkman, 1991). This program integrated projects done around authentic problems, project adventure, and field trips into an experience that was designed to build confidence and enthusiasm for doing science. Based upon the feedback received from youngsters and the longevity of the program, the program was successful. The success it had on continuing youngsters' motivation to learn beyond the summer experience was unexpected. Unsolicited feedback from parents and even teachers described how the experience renewed or inspired a greater interest in school.

The motivation for youngsters to do science was achieved by leading them to discover a pattern in the world around them. By examining their own laterality, for example, youngsters would discover that the frequency of right is much higher than left-handedness. This discovery often led to questions about the higher frequency of right handers, laterality in other animals, and the causes of handedness. Beginning science with a pattern like human laterality encouraged youngsters to take ownership in a question and its solution through a project.

Methodology

Curriculum development and training

A year-long curriculum was developed around the activities, games, and projects of Real World Science and pilot tested with 529 students from 6 middle schools in Massachusetts and Connecticut. Their teachers, who volunteered to participate, were trained through a series of workshops throughout the year to implement the skill training in their classrooms. Feedback from classroom testing was used to edit the curriculum for errors and improve delivery of training.

The curriculum emphasizes solving real world problems that requires students to ask the right question, discover patterns, risk predictions, and make connections. Problems for students to solve are created around human heredity, evolution, performance, and ecology. The curriculum includes activities and games that are designed to build thinking and cooperative learning skills.

Development of the self-efficacy instrument

Self-efficacy is the perception of one's ability to perform a specific task (Bandura, 1986). The curriculum is based on mastering discovery skills which are behavior tasks. An item pool was developed using statements covering four domains: recognizing patterns, asking questions, making predictions and seeing relationships. The item pool was examined by eight middle school teachers for validity. The instrument's response format measured confidence on a 4 point Lickert-type scale, where 1 represented "quite a lot" of confidence and 4 "very little."

Table 1

Pilot Sample Description N=348

AGE:		
	RANGE	11 - 13
	MEAN	11.8
	MEDIAN	12
	11	27.7% (93)
	12	64.9% (218)
	13	7.4% (25)
GRADE:		
	All subjects were in the 6th grade	
GENDER		
	Males	48.5% (165)
	Females	51.5% (175)
SCHOOL:		
	School 1	52.3% (181)
	School 2	47.7% (165)

Table 2

Discovery Skills Factors from the pilot study (n=332)

Item#	Item	Loading
People (α=.71)		
5	Discover that some **people** are different from the rest	.619
22	Ask questions about **people**	.579
13	Notice how **people** repeat doing things in a regular way	.427
20	Discover how **people** are related	.423
17	See how some sicknesses are different from the rest	.420
6	Make predictions about **people**	.415
4	Notice that **people's** habits fit together like pieces of a puzzle	.343
Factor 1 (α=.86)		
23	Discover that geological events like earthquakes and volcanos are related	.760
3	Discover what is common about geological events like earthquakes and volcanos	.692
15	Find that some geological events like earthquakes and volcanos are different that the rest	.645
11	Notice what is common about countries of the world	.572
7	Find out what is common about numbers	.560
2	Ask questions about the physical world of land, water and air	.559
10	Discover the events in history that repeat themselves	.522
19	Make predictions about numbers	.519
14	Ask questions about the living world of plants and animals	.483
9	Ask questions about social studies	.471
18	See how living organisms are related	.453
8	Notice how languages are related	.425
16	See that numbers repeat themselves in a regular way	.402
12	Discover that the world's continents fit together like pieces of a puzzle	.397

In June, 1993, the 23-item instrument was piloted with 348 sixth graders from two middle schools in Massachusetts. Table 1 describes the sample. The data were initially analyzed for mulivariate outliers and none were found. An exploratory factor analysis done on this pilot data, showed two common factors explaining 75.8% of the item covariance. Table 2 presents the item loadings and the internal consistency estimates for the pilot sample. Once factor dealt with "people" (Make predictions about people) and the other with numbers (Find what's common about numbers) and events (Discover what's common about geological events like earthquakes and volcanoes). Among the students in the pilot test, significant differences were with respect to gender on the people factor (see Table 3). Females were more confident on the people factor.

The revised instrument (two items that did not load on either factor were dropped) was used in a pre/post design to determine if the curriculum was effective in improving self-efficacy of discovery skills. The instrument was administered to the study sample, 180 sixth graders in one middle school in Massachusetts in the fall of 1993. The curriculum intervention took place over the 1993-1994 school year. The instrument was administered again in June 1994 to 169 students. Table 4 describes the study sample.

The factor pattern of the student sample did not match the pilot, so another exploratory factor analysis was done. Again two factors dropped out, explaining 69.5% of the item covariance. This time one factor concerned item dealing with people and numbers, the other factor with events. Table 5 shows the factor loadings of this new analysis.

Results and Discussion

A matched *t*-test was done on the 99 students who completed both administrations of the instrument (see Table 6). The people/number factor showed significance (pre mean = 2.29, post mean = 2.16, $t = 2.30$, $p < .02$) implying that the students got more confident at the discovery skills dealing with people and numbers.

Table 7 presents the results of a item by gender analysis on the pre data and Table 8 the results of the same analysis on the post group. Females were more confident about making predictions and asking questions about people.

Table 3

Comparison of Discovery Skills by Gender (n=340)

Factor	Male Mean(SD) (n=165)	Female Mean(SD) (n=175)	Mean Difference	Effect Size
People	2.31(.64)	2.06(.59)	.25***	.39
Factor 1	2.64(.71)	2.74(.57)	.10	

***$p<0.0001$

Table 4

Study Sample Description

Pre sample (n = 180)		Post sample (n = 169)
	AGE:	
10 - 12	RANGE	11 - 13
11.1	MEAN	11.9
11	MEDIAN	12
	GENDER	
53.1% (95)	Males	52.1% (88)
46.9% (84)	Females	47.9% (81)

All subjects were in the 6th grade in one school

Table 5

Discovery skills factors for the study (pre sample) (N=180)

Item#	Item	Loading
People/Numbers		
10	Make predictions about *numbers*	.767
15	See that *numbers* repeat themselves in a regular way	.583
6	Find out what is common about *numbers*	.534
5	Make predictions about **people**	.432
12	Notice how **people** repeat doing things in a regular way	.427
19	Discover how **people** are related	.349
4	Discover that some **people** are different from the rest	.340
3	Notice that **people's** habits fit together like pieces of a puzzle	.340
Factor 1		
14	Find that some geological events like earthquakes and volcanos are different that the rest	.671
8	Ask questions about social studies	.662
21	Discover that geological events like earthquakes and volcanos are related	.652
9	Discover the events in history that repeat themselves	.635
2	Discover what is common about geological events like earthquakes and volcanos	.552
1	Ask questions about the physical world of land, water and air	.547
17	See how living organisms are related	.334
7	Notice how languages are related	.393
18	Notice what is common about countries of the world	.394
13	Ask questions about the living world of plants and animals	.378
16	See how some sicknesses are different from the rest	.334

Table 6

Comparison of Discovery Skills Factors by Test time (n=99)

Factor	Pre Mean(SD)	Post Mean(SD)	Mean Difference	Effect Size
People/Numbers	2.29(.59)	2.16(.56)	.13*	.22
Factor 1	2.54(.56)	2.53(.52)	.01	

*$p<0.05$

Table 7

Item by Gender with pre data (n = 180)

Item	Male Mean(SD) (n=96)	Female Mean(SD) (n=84)	Mean Difference	Effect Size
Item 5	2.50(1.06)	2.20(.97)	.30*	.29
Item 14	2.58(1.00)	2.89(.84)	.31*	.33
Item 20	2.15(.96)	1.75(.82)	.40**	.44

*p<0.05
**p<.005

Item 5 Make predictions about people.

Item 14 Find that some geological events like earthquakes and volcanoes are different from the rest.

Item 20 Ask questions about people.

Table 8

Item by Gender with post data (n = 169)

Item	Male Mean(SD) (n=85)	Female Mean(SD) (n=81)	Mean Difference	Effect Size
Item 2	2.53(.95)	2.85(96)	.32*	.51
Item 5	2.24(1.04)	1.90(.88)	.34*	.35
Item 20	2.03(.99)	1.62(.80)	.41**	.45

*p<0.05
**p<.005

Item 2 Discover what's common about geological events like earthquakes and volcanoes.

Item 5 Make predictions about people.

Item 20 Ask questions about people.

The results show that discovery skills associated with pattern recognition in science can be enhanced through training. These results are significant in view of the fact that patterns run through the history of science (Judson, 1987). Watson and Crick beat their rivals to the structure of the double helix because Watson saw a telltale pattern in an X-ray photo of DNA. The science of epidemiology was invented from spot maps John Snow made of patterns of infection. And the periodic table was created when Dmitri Mendeleev recognized that chemical elements, arranged according to their atomic weights, exhibited a periodicity of behavior. In the field of ecology, the search for patterns is considered to be most critical (Weiner, 1995).

Because the work of science is the search for patterns, the work of schools should have the same goals. Theses goals are consistent with the goals of educational reform which emphasize the importance of giving students opportunities to create and solve problems in real world contexts. Patterns make connections, set up expectations, and raise burning questions. When students seek patterns in the world around them, they see order instead of chaos. This builds confidence in their understanding of how the world works and greater control over it. Moreover, it can be the motivation that "creates a need to know" about doing science. It is encouraging in view of the role patterns play in discovery, that students can be trained to become better pattern seekers.

Our results also showed an unexpected difference in pattern recognition between genders. Females were more confident in recognizing patterns in people and males more confident in seeing patterns in natural events. This seems to support observations that girls approach problem solving from the perspective of interdependence and relationships than from the isolated skill analysis viewpoint favored by boys (Blake, 1993). This suggests that males and females should be trained differently to compensates for their weaker skills. Because female middle school students appear to have more confidence in discovering patterns about people, by relating science to people patterns could contribute to encouraging higher female interest in science.

Discovery skills associated with pattern recognition in science can be enhanced through training. Because female middle school students appear to have more confidence in discovering patterns about people, relating science to people patterns could contribute to maintaining their interest in science.

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