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ABSTRACT

This report describes a program for advancing critical thinking skills in an integrated earth science geography course. The targeted population consists of high school freshmen from a growing, upper middle class, suburban community 40 miles west of Chicago. The information on these students comes from teacher observation, colleague surveys, and assessment of student work. Analysis of probable cause data reveals: (1) students are indifferent; (2) critical thinking strategies have not been developed sufficiently; (3) students do not make relationships within and between subjects; and (4) the traditional 50-minute classes cause learning to be segmented and interrupted. Student questionnaires, faculty surveys, and a review of current science curriculum document these probable causes. Solution strategies suggested by knowledgeable others, combined with an analysis of the problem setting resulted in a selection of three major interventions: (1) a change in the current 50-minute class structure; (2) a change of curriculum content; and (3) a change in instructional procedures. Tables, teacher questions, a teacher check list, and a teacher survey are included in the appendix of the research. Contains 19 references. (EH)

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IMPROVING HIGH SCHOOL STUDENTS CRITICAL THINKING SKILLS

by

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Submitted in partial fulfillment of the
requirements for the degree of Master's
of Arts in Teaching and Leadership

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Dedication

This research is dedicated to my students with a sincere hope that they will benefit from it, and in turn one day have a positive impact on the young people they find in their lives.

Abstract

AUTHOR: Daniel M. Fraker SITE: St. Charles High School
DATE: June 20, 1994

TITLE: Improving Student Critical Thinking

ABSTRACT: This report describes a program for advancing critical thinking skills in an integrated Earth Science Geography course. The targeted population will consist of high school freshman from a growing, upper middle class, suburban community located 40 miles west of Chicago. The lack of student critical thinking skills was documented through data gathered by direct teacher observation, colleague surveys, and assessment of student work.

Analysis of probable cause data reveals: students are indifferent, critical thinking strategies have not been sufficiently developed, students do not make relationships within and between subjects, and the traditional 50 minute classes cause learning to be segmented and interrupted. This detracts from an environment that fosters critical thinking. Student questionnaires, faculty surveys, and a review of current science curriculum were used to document these probable causes.

Solution strategies suggested by knowledgeable others, combined with an analysis of the problem setting resulted in a selection of three major interventions; a change in the current 50 minute class structure, change of curriculum content, and change in instructional procedures.

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Chapter 1

PROBLEM STATEMENT AND COMMUNITY BACKGROUND

General Statement of Problem

The targeted freshman of St. Charles High School in St. Charles, IL lack adequate critical thinking skills. This is evidenced by teacher observations and teacher-made tests in an average ability level freshman earth science class (hereafter referred to as level two students).

Local Context

St. Charles High School has a population of 2800 students served by a professional staff of 185. The high school is the single public facility serving students in grades nine through twelve. The school's population is 95 percent white, 0.3 percent Black, 2.0 percent Hispanic, 1.8 percent Asian, and 0.5 percent Native American. Two and one half percent of families fall in the low income range. One percent of the student body is eligible for bilingual education. The dropout rate is two and one-half percent (St. Charles High School Report Card).

The administrative team consists of one principal, two assistant principals, three full-time deans, two part-time deans, one athletic director, and eight supervisors of the subject area departments. The staff of the science department consists of 20 full time certified teachers; average years of teaching experience is 14, with 20 teachers having bachelors degrees and 13 with masters. The average age of the science department staff is 38. The 6 women and 14 men are responsible for all teaching levels of science ranging from basic science to college level chemistry and physics.

Part of the high school facility is approximately 21 years old. Three years after opening an addition was built to complete the high school, and a Fieldhouse was built approximately 13 years ago. During the recent school year a referendum was passed to construct a new facility to accommodate 900 students.

The average class size is 21. However, growth has been steadily increasing due to housing construction in this area. There are several science classrooms equipped with labs and classroom materials to facilitate the teaching of science. There are also five classrooms equipped with computers for each student. These classrooms are available to all teachers on a daily sign-out basis. Classes are 55 minutes long with some two hour block courses and a six minute passing period between classes. Every student is required to pass two years of science. Placement for incoming freshman is based on test scores and teacher recommendation from eighth grade. The majority of ninth graders begin with either Biology or Earth Science. There are two levels of ability ranging from average to accelerated.

Science IGAP scores for the 1992-93 school year were 289 with 55 percent at state standard and 32 percent above standard. Thirteen percent scored below the state standard. The 1993-94 scores increased to 300 with 47 percent at state standard and 41 percent above state standard. Twelve percent were below state standard. Eighty seven percent of St. Charles High School graduates continue their education at the college level; 57 percent at four year colleges or universities, and 30 percent at two year colleges (St. Charles High School Report Card, 1993).

The overall goal of the science department is to develop independent, creative, and critically thinking life long learners. Currently, the entire school faculty has identified the following areas for improvement: (a) communication, (b) creative and critical thinking, and (c) student responsibility.

Surrounding Community

St. Charles is a rapidly growing community with a population of 27,500 people within the city limits, and 11,814 residents who live north and west of the city limits (Census of Population and Housing, 1990).

The U.S. Bureau of the Census states that the average St. Charles family income is $58,041 which is considerably higher than the State average of $42,619 and the U.S. average of $40,297. Of these households, 58.1 percent have children; average family size is 3.61 persons.

The median value of a single family owner-occupied house in St. Charles is $204,536, as compared to Illinois value of $80,873 and the U.S. value of $79,098. Because current school funding is based on local real estate tax income, high property valuation and steadily escalating property values increase the funds available to District #303. Another asset is the tax base which the city derives from local business and industry.The area is prospering with a large, modern industrial complex on the city's east side. A large

shopping mall, and several grocery/strip malls, have opened during the last three years (St.Charles Financial Report, 1993).

In addition to new construction, wise use has been made of some of the older buildings as well. The Piano Factory is a complex of discount stores housed within a restored building located on the Fox River which runs through the middle of town. Other buildings have been renovated into antique shops and boutiques. A large resort, Pheasant Run, has convention facilities, a dinner theatre, and golf course which attracts business groups and visitors to the area.

Due to the many areas along the river which have been preserved as public parks, people can enjoy stretches of the Fox River, or bicycle along many miles of scenic paths. During the year, local festivals such as the Pride of the Fox, Scarecrow Festival, and the Canoe Races draw large crowds.

The downside to increased residential and commercial activity is a deterioration of the streets which are usually congested with traffic. Three bridges span the Fox River within the downtown. Further north of the downtown, where a bridge is desperately needed, preliminary plans have been drafted to construct a fourth bridge to alleviate the traffic congestion.

Easy access to expressways and the Chicago and Northwestern train system, which travels to Chicago, give St. Charles residents easy access to surrounding towns. Also, the adjacent DuPage Airport has expanded to include a golf course and club house in addition to its busy transport business.

Civic services include a large public library. Over 60 civic clubs and organizations exist.

Community involvement with the school system is evident. The Arthur Anderson Corporation has established a partnership with District #303 training administration and teaching staff in T.Q.M. (Total Quality Management). The St.

Charles Education Foundation develops funding for school projects that cannot be obtained thru conventional sources. An example is the acquisition of two multi-media systems in one of the elementary schools as a result of contributions from local corporations. Also, Professional Partners program is a collaboration between the school district and the Industrial Division of the Chamber of Commerce. Leadership is provided by the School District Superintendent and an industrial CEO while members of the group share information and expertise.

Parochial education facilities include a Catholic grade school located in the city of St. Charles and two secondary schools situated in nearby towns. Elgin Academy is a private school which offers instruction from K - 12. Access to college level programs is also available; Elgin Community College, College of DuPage, and Northern Illinois University offer tax supported programs within easy commuting distance.

Local, State and National Context of Problem

As students move from school to their niche in society, their ability to think critically and make wise, prudent decisions is as important today as it has ever been. This decision making process involves the use of critical thinking in a context that will determine our quality of life immediately and for years to come. As high school students become young adults, their ability to think critically is essential if they are to live, work and prosper in our current and ever changing society. Students must make decisions and judgments every day regarding information, present and future plans, and situations that require immediate action. As adults they will be living in a complex world where both individual and societies actions as a whole will require good judgment in the selection and use of information (Howe & Desinger, 1990).

Unfortunately, groups such as The National Commission on Excellence

do not see thinking skills improving. Their report, A Nation at Risk, 1983, indicates deficiencies in higher level thinking skills in American students (Marzano et al.1989). Educational journals, including Phi Delta Kappan, have also addressed the problem. They indicate the inability of students to adequately answer higher-level thinking questions, or to perform well on complex tasks (Bracey 1992). Testing by the National Assessment of Education Progress (NAEP) shows that students approach thinking tasks from a mechanical stand point without adequate thought to what it is they are actually trying to arrive at (Marzano et al 1989).

State and local curriculum guides include goals and objectives on critical thinking skills. National and state business reports on education have called for more emphases on critical thinking skills since 1983 (Howe & Desinger, 1990). Locally, our school district conducted a student testing prompt in May, 1994 by random sample which indicated 40 percent of the high school population need help with critical thinking skills.

As we progress as a society into the next century, the decisions we make, both individually and collectively, will follow us and be left as a legacy by which our childrens' children will judge us . In this light, it is imperative that all citizens be equipped with the mental tools (namely critical thinking skills) necessary to make wise prudent decisions.

Chapter 2

PROBLEM EVIDENCE AND PROBABLE CAUSE

Problem Evidence

In order to document the extent to which students lack critical thinking skills, 25 level two freshman in an integrated Earth Science / Geography class were given a problem solving prompt (Appendix A) in which they were to pick out the purpose, and variables associated with the reading. They were to then write a proposal to correct the problem. The researcher used a four level grading rubric (Appendix B) to score the proposed solutions. A summary of the results is presented in Table 1. Of the 25 students, 72 percent either need help or can only marginally identify the purpose of this prompt. Sixty eight percent need help or can only marginally identify variables. Eighty percent need help or can only marginally organize a solution. Finally, 60 percent need help or can only marginally show a process in problem solving.

To further document that targeted group of students (average ability freshman) lack adequate critical thinking skills, a teacher survey (Appendix C) was developed and given to 10 teachers of the targeted students. The teachers surveyed represent four academic disciplines (science, social studies, mathematics, and English), and were asked to fill out a survey describing why they believe level two (average ability level) students lack adequate critical thinking skills.

Table 1

Problem Solving Prompt N = 51

	Percent Needs Help	Percent Marginal	Percent Acceptable	Percent Exemplary
Establishes Purpose	40	32	24	4
Identifies Variables	28	40	32	0
Organization of Solution	24	56	20	0
Problem Solving Process	16	44	40	0

The survey asked the teachers the following questions: a) In your opinion, what percentage of level two freshman you have had in the past two years lack adequate critical thinking skills? b) For those students who do not have these skills, what do you believe is the underlying reason? c) Do you incorporate specific strategies in your lessons to address critical thinking?

Of the 10 teachers surveyed, half (5) believe only 10 to 25 percent of level two freshman have adequate critical thinking skills. Three teachers believe 25 to 50 percent do, and only two believe 75 to 85 percent do.

Regarding the second question, there appears to be two underlying themes as to the reason students lack critical thinking skills: a) lack of exposure to these skills, such as problem solving and applying learned knowledge to new situations, and b) students have been "spoon fed" content and have not had to think for themselves. As for the third question, all 10 teachers answered "yes," they do incorporate critical thinking strategies into their lessons.

Probable Cause

The literature suggests several underlying causes for the lack of critical thinking skills. Students would rather socialize than learn; assignments are only done for a grade, having no significant meaning to their lives; students have not been challenged, or given the opportunity to reflect on and to explain why they hold to certain assumptions and beliefs (Paul, Binker, Martin & Adamson, 1989). There are also fundamental obstacles in the educational system to achieving critical thinking skills. These include an over emphasis on standardized testing (Bellanca & Fogarty, 1990), and the fact that critical thinking is not an actual part of the traditional curriculum (Howe & Desinger, 1990).

The literature suggests students socialize in class beyond a reasonable degree because the information they are being presented does not require their

full attention. Usually when this is the case, students are being asked to write down facts and figures only to be recited back to the teacher at a later date in the form of a traditional test. It is no wonder students begin to socialize; they are looking for meaningful activity (Paul et al,1989).

Another underlying cause for inadequate critical thinking skills is that students feel apathetic toward assignments that appear to have no relevance to their lives. Assignments that are simply done for the sake of getting a grade, and make no real connection to what students experience outside of school will not lead students to begin to think about problems from different perspectives. This is essential in becoming a critical thinker (Paul et al,1989).

Students that are not given the opportunity to think out and explain their position on issues, opinions and beliefs are left to the mercy of others viewpoints. They do not reflect and evaluate reasons for their beliefs or opinions, they simply either agree, or disagree about an issue without understanding it. Lacking skills to analyze and evaluate, these students let irrelevant reasoning influence their decisions. Often these students do not notice or recognize assumptions, and are willing to accept something that sounds good (Paul et al,1989).

According to Bellanca and Fogarty (1990), the traditional assessment format (standardized tests) is another obstacle in getting students to think critically. The reason is this type of test dictates what and how teachers teach. All aspects of a students progress are driven by test results, everything from what level courses they will take in high school to what college they will attend. Unfortunately, many of these tests tell little, or nothing at all, of a students ability to think critically. Why then, we ask, are students poor critical thinkers? One reason is it is not easily tested (measured) and therefore not taught with the same zeal that subject content is, if at all.

"In general, data indicate that critical thinking skills are not learned well unless schools emphasize critical thinking and the use of critical thinking on a continuing basis. Focusing directly on thinking skills and the development and use of thinking skills over time tends to produce more effective thinking than unplanned emphasis on the skill development, or short term emphasis" (Howe & Desinger, 1990, p.12). Another underlying cause, then, is critical thinking skills have not been taught on a continual basis. Like so many other things in life the adage, practice makes perfect, also applies here.

The overall lack of critical thinking skills, then, can be attributed to one or more of the following: a) and inadequate curriculum design that does not interest many students or challenge them to think critically, b) too much student socialization, c) student apathy toward rote type assignments, d) students are not given the opportunity to think through and explain their view points, e) an over emphasis put on structuralized test scores, and f) it is not easily measured or tested.

Chapter 3

THE SOLUTION STRATEGY

Review of the Literature

In reviewing current literature on critical thinking, several probable solutions to improve student critical thinking were identified. Solutions vary depending on the nature of the subject taught, the context from which it is being taught, and the age of the person being taught (Brookfield, 1987). There are, however, consistencies among researchers who have had something to say about the topic. One perspective is that to be a critical thinker, and improve as one as well, people need to think about their thinking while they are thinking in order to make their thinking better (Paul, 1993). Critical thinking, then, is thinking which involves self improvement in thinking, and an understanding of one's thinking. This improvement comes when standards are used to assess thinking (Paul, 1993). Paul (1993) states . . . "to impose discipline and restraint on our thinking by means of intellectual standards - in order to raise our thinking to a level of "Perfection" or quality that is not natural or likely in undisciplined spontaneous thought". (p. 91)

Another recognized way to improve student critical thinking is by integrating subject matter. One way to accomplish this is by finding common themes, or overlaps between subjects and have teachers of those subject areas team teach these concepts.

It is preferred that teachers do this voluntarily. This is because teaching together, like a marriage, works best when people are doing something because they want to. Curriculum integration also requires that teachers have common planning time, and that student schedules are in back-to-back hour blocks (Jacobs, 1991).

Another approach to curriculum integration is called webbing (Fogarty, 1991). This is where a topical theme, such as inventions, is explored through a cross departmental approach. The theme is an overlay to the different subjects. For example: Inventions could include studying the physics of machines in science, reading and writing about those machines in English, and designing and building one in industrial arts (Fogarty, 1991).

An excellent model of integration that can be used to achieve better critical thinking skills is called networking. This is an approach to learning that lets the student explore new avenues of learning as they come up in their studies (Fogarty, 1991). An example is a student doing a study on minerals. A jeweler may show the student how the internal atomic structure of a gem is what gives it its physical appearance and properties. The student could look into the internal or atomic make up of minerals which would introduce them to chemistry and crystallography. In this way the student's network of knowledge, in various fields is able to grow .

Integration does not have to happen one particular way. What is important is that knowledge is not segmented, and compartmentalized thus causing the student to see no relationship from one subject to the next.

Critical thinking is also enhanced by moving from a teacher centered, to a student centered classroom (Paul et al,1989). In a teacher centered classroom, teachers are engaged while students listen passively. Usually

teachers are giving statements, not asking questions. When teachers do ask questions, they may not give enough wait time needed for students to think about, and answer thoughtfully. Even if every student has a thoughtful, good answer to a question, only one or two can be called on by the teacher. Also, many teacher questions directed at the entire class are simple (skinny) recall questions. It is also not uncommon to have the teacher take a complex notion, and reduce it to its simplest parts. This is the exact opposite of one aspect of critical thinking (Paul et al,1989).

In a student centered class, students explore and research topics. They come up with questions of their own to answer. The teachers role becomes more of a guide, or coach, helping students to channel their thoughts and questions, and asking questions right along side them. This enables students to become better thinkers as well as learners (Paul et al,1989).

Another tool that can be used to develop critical thinking is cooperative learning. Cooperative learning is a process that is different from traditional learning, and classroom teaching (Foster, 1993). In this approach curriculum is organized around student tasks. There are six essential steps the teacher must take to begin cooperative learning. First, the teacher should arrange the room to allow students to face each other when working in groups. This encourages students to help, share and support one another (Bellanca & Fogarity, 1991). Second, choose the number of students to be in each team. A reasonable number is four, chosen by the teacher, or at random, and changed every six to eight weeks (Foster, 1993). Third, make the groups with mixed ability and ethnicity. Fourth, prepare students for cooperative work by teaching social skills. This is done over a period of time. Learning will not be productive unless members in the group learn skills of leadership, decision-making, trust-building, communication,

and conflict management (Johnson & Johnson, 1990). Fifth, plan teaching material and instruction for cooperative groups. Materials and instruction need to be structured in a way that allows each student responsibility for the group work (Artzt & Newman, 1990). Group members need to be reliant on each other to complete the task. Sixth, explanation of the team task for the day is vital for learning (Foster, 1993). Once the cooperative classroom has been established it provides an atmosphere that foster and enhances critical thinking. This is because students are interacting with information and each other in a format that requires them to reason out (and reason out loud) why they are doing a task, or activity a particular way. Another model of cooperative learning is an approach that is based on the criterion, analysis, and application of content-free structures that cause students to interact positively toward one another in the classroom (Bellanca & Fogarty, 1991). These fall into three main categories. Within these contexts, students take a turn in a prescribed order jigsaw, where each student has a part of the information to study, and teach the others in their group.

While these approaches to cooperative learning have their own unique attributes, no one approach is totally sufficient, or superior (Bellanca & Fogarity, 1992). Cooperative learning is a necessary tool for teaching, and building critical thinking skills such as keeping an open mind, seeking accuracy and clarity, avoiding premature judgment, and considering external feedback. A classroom where students can work productively, and cooperatively in small groups will also create an inviting learning environment (Clark, Wideman & Eodie, 1990).

Alternative approaches to assessment are the final tool addressed concerning improving student critical thinking. Observation checklists (Appendix D) are one approach to measuring critical thinking skills. This is

done by listing specific skills that are being sought on a particular assignment, and observing if students have mastered them. The checklist may use a check (/) for sometimes; a plus (+) for frequently; and a zero (0) for not yet (Burke, 1993). Not every student need be observed on one assignment, rather four, or five students are concentrated on for one assignment, and another four, or five in the next. This continues so the teacher can gain sufficient insight into each students' thinking skills thereby knowing which skills need more development, and incorporating them into future lessons (Burke, 1993).

Observation checklists are also helpful in letting teachers know early on who needs help the most before a quiz, or test is failed. This allows time for the teacher, and student to address the problem areas to achieve better test results (Burke, 1993).

Another assessment technique is the interview, or conference. Teachers are often reluctant to use this method because they feel it is too subjective (Burke, 1993). This may be an unfounded fear, however. Parents use this approach indirectly on a daily basis to get to know their child, and attain feedback from them. If used to check for specific skills, teachers can use this technique, and have confidence in it (Burke, 1993). Often it is used to determine if a student has grasped the purpose, central theme, or some detail of a particular activity. If they have not, it is an opportunity for the teacher to give direct feedback, and have the student clarify. Interviews can also be used to detect the mastery of certain critical thinking skills such as recognizing bias, making connections, and keeping an open mind.

Portfolio entries can be used to assess a students progress over a longer period of time than the previous assessment technique (Burke, 1993). Here, a student chooses a piece of work they have recently completed based on criteria

given by the teacher. For example, a teacher may ask a student to pick out what they feel is their best work for that week, or the criteria maybe to choose a piece of work the student feels they could have done better on, or that is still in progress. The student then answers teacher made questions about the work they have chosen to include in their portfolio. This tag sheet, as it is sometimes called, is attached to the work, and they are both put into a folder with the students name on it (Burke, 1993). New entries are added on a consistent basis, thus giving the student, parents, and teacher a view of a student progress. This process requires students to reflect on their thinking. It requires them to discuss not only what they did in a particular assignment or activity, but how and why they did it. What was their process for approaching it. They can also discuss any problems encountered, and how they were resolved. It also provides an opportunity for students to get external feedback from their peers, teachers and parents, and to clarity their work to these people. In this approach, the critical thinking skill of considering feedback from others is developed.

Portfolios can be used as an assessment tool although they do not have to be (Burke, 1993). If they are, one grade may be assigned for the entire body of work based on criteria that have been set by both the student, and the teacher. Another approach is to grade each piece separately based on the criteria of each particular assignment (Burke, 1993).

Projected Outcomes and Solution Components

As a result of changes in course content, assessment techniques, and integrating curriculum during the period of October 1994 to January 1995, the targeted freshmen at St. Charles High School will improve their critical thinking skills as measured by teacher observation, student assessment, and post test prompt.

Strategic Procedures Involve:

1. Learning activities that address critical thinking skills will be developed for an integrated course curriculum.

2. Units which integrate subject matter, and incorporate critical thinking skills will be developed.

3. Assessment techniques that authentically measure critical thinking skills will be developed.

Action Plan For The Intervention

Strategic Procedure #1 & #2

Astronomy/Astrology Poster Presentation (8 Class Periods)

This is part of a six week long unit on science and societies. In this project, after studying early astronomy in its historical context, students were assigned an ancient civilization and were to research how that civilization incorporated the stars (astrology) into their daily affairs. Students worked in groups of four, and each was required to research a particular aspect of the civilization (Appendix E). This information was put in a poster format using pictures and writing; each group presented their findings to the other groups in the class and to the teacher. A rubric was used for assessment of this assignment (Appendix F). Students also assessed each other posters using the rubric (though this does not determine their grade. This is done by the researcher). This approach fosters critical thinking in that it allows students to compare and contrast ancient civilizations and what type of reasoning these civilizations used to order their lives. During class discussions,students are expected to look for parallels between our and other cultures.

Create An Alien (4 class periods and part of the unit on science and societies)

In this activity, students work in pairs and are assigned a planet in our solar system. Based on the physical and chemical characteristics of the planet, its atmosphere (if it has one), its size, and distance from the sun, and other information students look up, they were to create a life form that could exist on the planet (Appendix G). This activity is an excellent way of getting students to apply information they have learned (in this case about the planets) to a new situation. They need to create and describe what a life form might look like that could live on a planet other than earth. This activity also gives opportunity to develop unique and original ideas. The alien was evaluated based on the description of its various parts and what their function is. That is, how do they enable it to live on the planet. The list of factors in Appendix G was used as a comparison when evaluating.

Estimating Orders Of Magnitude Activity (2 class periods and part of the unit on science and societies)

In this activity students similate the stars in the night sky with the holes in the ceiling tiles of their classroom. They are to devise a method they can use to estimate the number of holes in the ceiling tiles (Appendix H). This addresses the critical thinking skills of forming a hypothesis, decision making strategy, and problem solving.

Earth History Poster Presentation (10 class periods)

This was part of a six week long unit on geologic and human history. Students, working in pairs, are assigned a period of geological history (Appendix J). This assignment is similar to the Astronomy/Astrology poster presentation in its format. Students are to identify and present the beginning, peak, and ending of a particular geological time period to the teacher, and each other.

This was be done incorporating methods used to study history (i.e. time line and artifacts). Students were expected to present and communicate findings clearly and accurately. This was accomplished using the poster presentation format described in the Astronomy/Astrology project. It is graded using the poster presentation rubric (Appendix F)

Siting A Sanitary Landfill (15 class periods)

This was part of a six week unit on geology and land use. Using information learned in geology and local government, this project gave students the opportunity to site a new landfill in their township. Multiple critical thinking skills were used in this lengthy project including: gathering meaningful information, problem solving, decision making strategies, generating relevant questions, synthesizing information, drawing inferences, constructing support for a position or decision, considering external feedback, and keeping an open mind. The map they produced was graded based on the location of their landfill, their verbal defense of the location, and a formal written proposal which addresses the environmental and social concerns of their chosen site.

Strategic Procedure #3

The assessment techniques used in these units include the following: a) grading rubric for the poster presentation, b) a comparison chart (Appendix G) for the alien activity, c) determining if students formed a defendable technique in the orders of magnitude activity, and d) a student written proposal for the landfill activity. These assessment techniques were also discussed in strategic procedures one and two.

Chapter 4

PROJECTS RESULTS

Historical Description and Intervention

The object of this project was to improve high school students critical thinking skills. The implementation of learning activities that address critical thinking skills, integrated curriculum, and assessment techniques that authentically measure critical thinking skills were selected to accomplish this.

The first of the learning activities was an Astronomy/Astrology Poster Presentation (Appendix E) that was eight class periods in length and part of a six week long unit on science and societies. For this, students worked in groups of four where each was responsible for researching particular pre-determinded information on an ancient civilization and how they used the heavens to order their lives.

Create An Alien was the next activity (Appendix G). It was a four hour class period activity and part of the unit on science and societies. Students worked in pairs and were assigned a planet, created an alien life form, and described how it would look based on the physical and chemical make up of the planet. The alien's physical appearance was directly linked to the planets environment.

An Earth History Poster presentation (Appendix J) was the third of the learning activities. It was 10 class periods in length and part of a six week unit on geologic and human history. For this, students worked in pairs to research and present the beginning, peak and the end of a given geologic time period.

The final learning activity used to improve students critical thinking skills was siting a sanitary landfill. This activity allowed for 15 class periods and was part of a six week unit on geology and land use. Students used topographic maps, township maps, their county's soil survey, and literature on modern landfills to determine where it would be most environmentally and politically feasible to site their landfill.

A second approach used to increase student critical thinks skills was the development and implementation of an integrated Earth Science/ Geography course. This consisted of six-week units in Science and Societies, Geologic and Earth History and Geology and Land Use. Learning activities (which included an Astrology Poster presentation, create an alien activity, orders of magnitude activity, Earth History poster presentation, and siting a landfill) were implemented in this two-hour per day, team taught class.

Finally, the use of assessments, and techniques for evaluating them, that authentically measure critical thinking skills were developed to measure student critical thinking. These included poster presentations, a written proposal, and teacher made tests.

Presentation and Analysis of Results

In order to assess the effectiveness of improving student critical thinking skills, a teacher check list (Table 2) was used during the Astronomy/Astrology Poster Presentations, Create An Alien Activity, Earth History Poster Presentation and Siting a Landfill Activity. During the Astronomy/Astrology Poster Presentation the researcher chocked for the first, second and ninth categories in

Table 2. During the Create An Alien Activity the first, second and fifth categories were checked. For the Earth history project the third, fourth, fifth and ninth category. Finally, for the Landfill Site Activity the seventh, eight, ninth and tenth category. These data were then aggregated by month and are presented in Table 2.

Table 2

Teacher Check List of Critical Thinking Skills

Critical Thinking Skills	Sept.	Oct.	Nov.	Dec.	Jan.
1. Makes Connections	3	-	12	10	10
2. Draws Inferences	2	5	-	9	-
3. Classifies/Categorizes	2	-	-	4	12
4. Sequences	-	4	-	6	8
5. Analyzes for Cause and Effect	-	7	-	4	9
6. Analyzes for Bias	-	-	8	4	5
7. Constructs Support for Position or Decision	3	7	8	3	8
8. Avoids Premature Judgment	1	3	5	-	10
9. Applies Knowledge to New Situations	4	5	6	6	12
10. Weighs Consequences	-	-	5	-	7

Since no one assignment addressed all 10 of the critical thinking skills, the researcher focused on the skills which lend themselves to each particular lesson. Therefore, the reader should look for an overall increase in the number of observations, not any single category. It is clear there was an overall increase in the amount and types of critical thinking skills as a result of the intervention. Of particular note are the months of October and January which saw the greatest increases respectively. A second means of assessing the effectiveness of this project was to conduct a pre-post test at the onset of the project and upon its conclusion (Appendix A). A comparison of the results is presented in Table 3.

Table 3

Comparison of Pre and Post Test Results From Problem Solving Prompt

		Percent Needs Help	Percent Marginal	Percent Acceptable	Percent Exemplary
Establishes Purpose	Pre	40	32	24	4
	Post	20	18	43	19
Identifies Variables	Pre	28	40	32	0
	Post	16	20	55	9
Organization of Solution	Pre	24	56	20	0
	Post	22	31	39	8
Problem Solving Process	Pre	16	44	40	0
	Post	9	27	55	9

Here too, the intervention appears to have had a positive effect on all aspects of the problem solving prompt. Two areas worth noting are the increase of students scoring exemplary and the significant shift of students from the marginal category to the acceptable category.

Conclusions and Recommendations

Based on the presentation and analysis of the data from the researchers check list of critical thinking skills, as well as data and analysis of the pre-post test problem solving prompt, students showed a considerable increase in critical thinking skills. The integration of curriculum, and the development of units and activities which addressed an underlying theme was of great value. This allowed students the freedom to see how information is used to help form and make decisions in our society and others. The questions raised in class by students showed they were looking beyond a given assignment and at what some of the underlying problems are that we face today.

The assessment techniques used were also of much greater use than traditional tests at measuring critical thinking skills. They gave students the opportunity, and responsibility to apply concepts and information to situations that ranged from prehistoric time to the present day in their own community.

Some final recommendations to who ever else may be addressing increasing students' critical thinking skills. First, an integrated curriculum context is an excellent format to work from. By its very nature, curriculum integration addresses learning from a more thought provoking and problem based view point. This inevitably leads to the characteristics exhibited by good critical thinkers. Second, use learning material that has a local context and a direct impact on students lives outside of school. Last, be flexible and open to new ideas from both your students and other colleagues. They may sometimes have an idea that will make a good activity even better.

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Appendices

Appendix A

Problem Solving Prompt

You have been hired by a local government to help bring stream and river pollution in the area under control. The water shed you are working in is primarily agricultural use. There is some light industry, a growing housing market along one side of the main river, and a metal finishing plant one mile out of town, and one-half mile from the nearest stream. There is an old land fill (garbage dump) that is no more than 50 yards from one of the streams that flows into the main river.

The town has a sewage treatment plant that is 12 years old. Boats use the river for recreation, and there is a marina on the water front for service and refueling.

*** YOUR TASK ***

Propose a plan you will use to address this towns water pollution problem.

Appendix B

Scoring Rubric For Thinking Critically: Problem Solving Prompt

Criteria	Needs Help	Marginal	Acceptable	Exemplary
States Purpose	Purpose not apparent or vague.	Establishes purpose.	Establishes an appropriate purpose.	Establishes an appropriate purpose. Sets out a direction.
Identifies Variables	Only the most obvious variables.	Identifies variables.	Identifies variables and states why they are so.	Identifies all variables and and gives insight as to which may be most significant.
Organization Of Solution	Uses no apparent organization pattern.	Uses a sporadic or incomplete organizational pattern.	Uses a logical consistent organizational pattern.	Presents fluent and logical organization in a way that is original and unique.
Problem Solving Process	No process is established.	Some steps present but illustrate no understanding of a process.	Evidence of a process is present but it is loosely structured.	Process is clearly identified in a logical sequence in which the major components are included.

Needs Help: There was no evidence of the required skill and direct instruction is necessary for improvement.

Marginal: There was little evidence of the required skill and direct instruction necessary for improvement.

Acceptable: There was evidence of the required skill and direction instruction would help move the student to the next level of competency.

Exemplary: There was evidence that the required skill was mastered by the student.

Problem Solving Process: The task required the students to generate a problem solving process to address the issue presented in the prompt.

Appendix C

Teacher Survey

1. In your opinion. What percentage of freshman you have had in the past two years have adequate critical thinking skills?

   a. 0-10% b. 10-25% c. 25-50% d. 50-75%

   e. 75-85% f. 85-100%

2. For those students who do not have this skill. what do you believe is the underlying reason?

3. Do you incorporate specific strategies in your own lessons to address critical thinking skills?

   Yes No

Appendix D

Critical Thinking Teacher Checklist

1.	Makes Connections	_____
2.	Draws Inferences	_____
3.	Classifies/Categorizes	_____
4.	Sequences	_____
5.	Analyzes for Cause and Effect	_____
6.	Analyzes for Bias	_____
7.	Constructs Support for Position or Decision	_____
8.	Avoids Premature Judgment	_____
9.	Applies Knowledge To New Situations	_____
10.	Weighs Consequences	_____

Appendix E

Astronomy/Astrology Poster Presentation

Earth Science/Geography Fraker/Stepien

ASTROLOGY - "The First Science"

Although the uses of Astrology have changed over the years, many scholars consider it to be one of the first attempts by humans to make sense of their physical surroundings. Early civilizations made tremendous advances through the use of "signs from the stars." Your task will be to investigate some early civilizations and their uses of Astrology, and present them to us in a Poster Presentation.

Your research should focus on the following topics:

1. BACKGROUND OF THIS CIVILIZATION We need to know some fundamentals about this group of people, which will provide the context for the rest of the project. Focus on the following questions:

When did they flourish?
Time lines are always helpful . . .
What was their basic system of economics and government?
This will tell us what they did to survive and how they were ruled.
How did they divide up into "social classes?"
Who was considered important? Why?
What were some of their major accomplishments?
Did they accomplish anything important or unique?
How and when did they decline?
Nothing lasts forever . . .

2. USES OF ASTROLOGY Finally!

How did they use astrology?
Describe what they observed and what it meant to them.
What kinds of people used it?
Was it used by everyone or only certain people?
How does it show up in their Mythology?
Most of these cultures use astrology in their mythology or use mythology to describe the creation of the universe. Find an example!

After sharing your posters with us, we will be asking you to rate the most important uses of Astrology to these people, based on your knowledge of their civilization and how they used it. You are to hand in a one page explanation of your reasons after your presentation (Please type!)

DUE DATE:

POSTER PRESENTATION GRADING RUBRIC

Dimension	Exemplary	At Standard	In Progress
VISUALS	Visuals are relevant and enhance viewer's understanding of topic Poster is well-organized and has a logical flow Pictorials are of high-quality	Visuals are relevant Posters are well-organized and fulfills all aspects of the assignment Pictorials are adequate	Visuals not relevant or nonexistent Posters are not organized and do not fulfill all aspects of the assignment Pictorials are low-quality or hard to understand
WRITTEN DESCRIPTIONS	Information accurate and detail shows understanding of complex ideas Information relevant to assignment and is of high-quality Writing is well-organized with a logical flow Use of language is excellent and enhances reader's understanding of topic	Information accurate and is sufficiently detailed Utilizes relevant information and only minimal - relevant information Writing is organized and fulfills entire assignment Very few spelling and grammar mistakes - do not not distract reader	Information inaccurate or vague Utilizes a significant amount of irrelevant information Writing is not organized and assignment is not complete Sloppy and hard to read. Spelling and grammar make writing hard to follow
VERBAL EXPLANATION	Utilizes conversational tone and obviously understands material thoroughly Poised and confident Answers questions clearly and thoroughly	Speaks from notes or memory using a comfortable tone - shows basic understanding Generally poised and confident Responds to most questions with clarity	Merely reads from notes and shows little or no understanding Appears indifferent, anxious, or nervous Has trouble responding to questions
USE OF SOURCES	Uses high-quality, credible sources Identifies bias in information at a complex level Utilizes source information within own particular style	Gets information from relevant sources Identifies bias at the most basic level Utilizes source information in their own words	Gets information from irrelevant, low-quality sources Can not identify bias Copies from sources - can not articulate in own words

BEST COPY AVAILABLE

INVENTING AN ALIEN

Instructor Guide

These are some implications for an alien creature to exist on each of the planets.

MERCURY

- No atmosphere...nothing to breathe; respiration should be by some other means.
- Low surface gravity...about one-fourth of that on Earth; able to jump great distances/heights.
- High surface temperature...must have some means of protection from intense radiation.
- Low surface pressure...must have a rigid skeleton with low internal pressures.
- Rocky surface...locomotion must take it over rough terrain.

VENUS

- Atmosphere...must be able to breathe carbon dioxide.
- Surface gravity...comparable with Earth; similar abilities to jump and move around.
- High surface temperature...must have some means of protection from intense heat, which could melt lead.
- High surface pressure...90 times that on Earth; must have an extremely rigid skeleton with high internal pressures.
- Rocky surface...locomotion must take it over rough terrain.
- Sulfuric Acid clouds...must have protection.

MARS

- Little atmosphere...must be able to breathe carbon dioxide.
- Low surface gravity...about one-third of that on Earth; able to jump moderate distances/heights.
- Low surface temperature...must have means of generating internal heat.
- Low surface pressure...must have a rigid skeleton with low internal pressures.
- Rocky surface...locomotion must take it over rough terrain.

JUPITER/SATURN/URANUS/NEPTUNE

- Atmospheres...must be able to breathe hydrogen, with small amounts of helium and methane.
- Surface gravities...comparable with Earth (except Jupiter).
- No surfaces...these are gas planets, so there is no "surface" as we know it; nothing to stand on.
- Low temperatures...must have means of generating internal heat.
- Unknown surface pressures...these will be pure speculation.

PLUTO

- Little atmosphere...must be able to breathe methane.
- Low surface gravity...about two-hundred times smaller than on Earth; able to jump incredible distances/heights.
- Low surface temperature...must have means of generating internal heat.
- Low surface pressure...must have a rigid skeleton with low internal pressures.
- Icy surface...locomotion must take it over icy terrain.

Appendix H

Orders Of Magnitude

FERMI QUESTIONS
or
ESTIMATING ORDERS OF MAGNITUDE

A Fermi Question has an answer that cannot be easily measured, if at all. They are thought questions that have orders of magnitude as acceptable answers. For example, suppose you were asked to determine the following:

HOW MANY LEAVES ARE THERE ON A TYPICAL LARGE TREE IN THE SPRING?

Well, first you would have to make several assumptions about the tree.

1. The tree is a cube, perhaps 10 meters on a side. As a result, the volume of the tree would be:

   $$\text{Volume} = 10 \text{ meters} \times 10 \text{ meters} \times 10 \text{ meters} = 1000 \text{ m}^3, \text{ or}$$

   $$\text{Volume} = 10^3 \text{ m}^3$$

2. The leaves are symmetrical and uniformly distributed.

3. Ten leaves lying end-to-end are 1 meter in length. As a result, the number of leaves per cubic meter is:

   $$\frac{\text{number of leaves}}{\text{unit volume}} = \frac{10 \text{ leaves}}{1 \text{ meter}} \times \frac{10 \text{ leaves}}{1 \text{ meter}} \times \frac{10 \text{ leaves}}{1 \text{ meter}} = \frac{1000 \text{ leaves}}{1 \text{ meter}^3}, \text{ or}$$

   $$\frac{\text{number of leaves}}{\text{unit volume}} = \frac{10^3 \text{ leaves}}{\text{m}^3}$$

If we know the number of leaves in every cubic meter of space for this tree, and the total number of cubic meters, we can estimate the number of leaves on the tree:

$$\frac{\text{\# of leaves}}{\text{cubic meter}} \times \text{\# of cubic meters} = \text{\# of leaves}$$

$$\frac{10^3 \text{ leaves}}{\text{m}^3} \times 10^3 \text{ m}^3 = 10^6 \text{ Leaves, or}$$

ONE MILLION LEAVES ON A TYPICAL TREE!

Now you will have a chance to do these calculations. On the other side of this sheet you will find a selection of Fermi questions. When you have found the answers, we will share them as a group. Be sure to show all assumptions and the resulting work of your efforts. DO NOT GUESS!!

Appendix I

Teacher Made Test

Name:_____

From: World Science Federation

To: Spacecraft Captains

You have been selected to embark on a voyage of space exploration and discovery. to seek out and explore new planets and life forms. To boldly go where no one has gone before!

You destination is the star DENEB in the constellation CYGNUS. It has a Parallax Angle of .008" as seen from Earth. You will need to supply the World Space Federation with the following information before funds are made available to you to begin your voyage:

1. Distance to the star in light years (Show All Calculations, or funds will be withheld).

2. What season of the year will you launch from the U.S.A. during DAYLIGHT hours?

3. How long will it take you to get there traveling at 100,000 M.P.H. (Show All Calculations, or funds will Be Withheld). Give answer in Years, and Generations. Figure there are 70 years in one generation.

4. What suggestions do you have to "Speed Up" your ship?

5. What are the current Surface Temperature and Absolute Brightness of your star?

6. What Stage of Life is your star in as seen from Earth?

7. How will you determine the Chemical Makeup of your star?

8. Will your star most likely show a Red Shift, or Blue Shift and Why?

9. What stage of life will your star be in when you arrive assuming you are traveling at 100,00 M.P.H.? Explain your reasoning.

10. Will your star be there when you arrive? Explain. Good Luck, Captains and God's Speed!

Appendix J

Earth History Assignment

Concepts: Rate of change

- What makes change happen
  -
  -
  -

Introduction: Life form changes

Assignment: Given a geologic time period, or era, explore and describe the onset, peak and demise of that time in the geologic past. Use both written and pictorials (poster) to discuss in detail the assigned period. Include outdated and current, accepted theories regarding the above.

Sources: Use various sources

- Text Books
- Encyclopedias
- Magazines
- Journals
- Museums
- Computer Search

Due Date: