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ABSTRACT

In 1989 a study was conducted at Pima Community College (PCC) to assess students' knowledge of basic physical science concepts. A three-part survey instrument was administered to students in a second semester sociology class, a first semester astronomy class, a second semester Spanish class, and a first semester physics class. The survey instrument sought to determine students' opinions about certain scientific topics, assess th ir knowledge of and ability to apply 12 basic scientific facts, and gather demographic data. Study findings, based on questionnaires completed by 89 students, included the following: (1) over 50% of the students missed the questions on energy, reaction rate, photosynthesis, relativity, and projectile motion; (2) students who had completed college-level science (CS) courses had significantly higher test scores than students who had only completed high school (HS) science courses; (3) 30% of the HS students and 18% of the CS students agreed with the statement that "some numbers are especially lucky for people"; (4) 31% of the HS students and 15% of the CS students agreed with the statement that "In this complicated world of ours, the only way we can know what is going on is to rely on leaders and experts who can be trusted"; (5) 15% of the HS students and 3% of the CS students agreed with the statement that "It is not wise to plan ahead because many things turn out to be a matter of good or bad luck anyway"; and (6) 46% of the HS students and 50% of the CS students agreed that "human beings as we know them today developed from earlier species of mammals." Based on study findings, it was recommended that all PCC students be required to take one physical science course. Two versions of the survey instrument are attached, along with critiques from a panel of experts on the first version. (JMC)

PIMA COLLEGE STUDENTS' KNOWLEDGE OF SELECTED BASIC PHYSICAL SCIENCE CONCEPTS

by

David G. Iadevaia, M.A.T.

Pima Community College

A Practicum presented to Nova University in partial fulfillment of the requirements for the degree of Doctor of Education

Nova University

November, 1989

ABSTRACT

According to the literature the importance of a knowledge of science and technology by the general population is at the forefront of decision makers' thoughts. Various polls of public opinion regarding this issue seem to provide contradictory data from which are formed conflicting positions. When Science Indicators, the journal produced by the National Science Board whose purpose it is to ascertain public opinion of science and technology, reports conflicting and contradictory conclusions, confidence, at best can be shaken in opinion polls. At worst, one can conclude opinion polls should not be used to base major changes in science education.

The literature, however, indicates that work has been done to address the accuracy of opinion polls. A survey by Miller (1987), which has been used for the past ten years, indicates that determining the scientific literacy of the general public should not be based on opinion about science but on knowledge of scientific fact. It is one thing to have an opinion about something and quite another thing to know about it. It is from this point of view that this research project was conducted.

Data for this research study was collected from a survey which was designed as part of this study. The data was then compiled using an appropriate computer program. Two groups were selected, those who have had previous

college level science courses and those who have not had college level science courses were compared. It was found that there was a significant difference ($p=0.05$) between the two groups. It seems that scientific literacy, as measured by the survey, was dependent on previous college level science courses.

Miller (1987) concluded that people with college level science courses showed a greater scientific literacy than those without previous college level science courses. This study confirmed Miller's conclusion. It was also found that an opinion about science does not necessarily mean an understanding of content. Miller's statement regarding opinion was proved correct by this study.

It was recommended that all programs, both degree and non-degree, at Pima College included a basic physical science course. This recommendation was not only based on the confirmation of Miller's work but on a simple analysis done on the content questions of the survey. This analysis showed a weakness in some basic physical science knowledge.

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INTRODUCTION

The state of science education in the United States has been reported in professional journals and the popular media for a number of years (Beveridge and Rudell 1988) also (Vagelos 1989). The data on which these reports are based have been compiled from public opinion polls. These polls are now being examined closely as to the accuracy of the conclusions drawn from poll data (Schuman and Scott 1987). There is confusion as to the equivalence of opinion and knowledge about a subject. The application of opinion to a problem versus knowledge about the problem must be addressed. Since all aspects of science education, from curriculum design to funding, are derived from needs, either perceived or real, it is very important to establish as accurately as possible the problem with science education (Yaeger and Penick 1988). If the public is indeed scientifically illiterate, it is important to know what that means in order to take corrective steps to increase literacy. It is from this perspective that this study was conducted.

Nature of the Problem

The problem of scientific literacy may be addressed from the previous educational experience of a person. The work of Jon Miller, according to Culliton (Culliton

1989). has indicated that the fact that a person has had previous college-level science courses is a good predictor of a person's scientific literacy. The student population of Pima College should reflect this as well.

Purpose of the Study and Recommendation

The purpose of this study was to compare previous science courses taken and scientific literacy, to the national science literacy surveys in order to better interpret the national results. Based on this interpretation, a second purpose was developed, to use the results of the study as documentation to support a recommendation to the Pima College administration that all students attending the college must have at least one physical science course in their program of study.

Literature Review and Significance of the Study

The premier publication of the National Science Board, Science Indicators: The 1985 Report, regarding public opinion of science and technology has apparently failed to apply poll results objectively. According to Beveridge and Rudell (1988:384):

> Our careful reading of PATSAT (Public Attitudes Toward Science and Technology) led us to pose a series of questions, which required recourse to original instruments and in some cases to the data themselves. When materials were forthcoming our suspicions of errors in classification and analysis proved justified.

The importance of this resides in the fact that decision makers in government rely on this publication in order to address important issues regarding science and technology. One of these issues is science education. A contradictory conclusion is pointed out by Beveridge and Rudell (1988:382):

> The six data points reported . . . also could be viewed as evidence of two other seemingly contradictory trends: (1) Increasing support for science comparing the average of 1972, 1974 and 1976 surveys (54.3%) with the average of 1983, 1984 and 1985 surveys (64.7%) (2) Decreasing support for science in the 1980's from 73% in 1983 to 63% in 1984, to 58% in 1985.

This is an example of one applying the outcome of research to a particular end. If it is necessary to decrease funding for science education one could invoke trend number one. If it is necessary to increase funding for science education one might invoke trend number two.

Problems seem to exist with survey questions in general. These problems would also affect the outcomes of surveys. As stated by Schuman and Scott (1987:957):

> A seemingly simple way of assessing public opinion is to ask a random sample of the public to choose from among an explicit or implicit set of alternatives. The form of the question, however, can greatly affect such choices.

This might indicate that the questions of the survey may be posed to elicit a desired response. A response that will be used to support a pre-determined position. It would seem that one survey regarding public opinion of science and technology is as good as another.

However, scientific literacy might be another matter. It is one thing to have an opinion of a subject, but quite another to know something about a subject (Miller 1987). When it is reported that "studies find only 6% of Americans and 7% of British meet standards for science literacy" (Culliton, 1989:600) this is cause for concern. If the concern is about actual knowledge of science then there is a problem.

The results of a survey, developed by Miller (1987) over a ten year period, according to Culliton (1989:600), has been used to test "an understanding of the process and methods of science, a basic vocabulary and recognition of the impact of science and technology on society". This survey is described by its author as the "best measure so far". It was from this perspective that this research

practicum was conducted. Based on Miller's work, Culliton goes on to state (1989:243):

> Miller examined five variables: gender, age, level of education, science courses in college, and employment in a science related company. A college level science course is the "predominant, single most important" predictor of science literacy."

For this study only previous high school and college level science courses taken were compared by score on the content part of the survey.

Relationship of the Study to the Seminar

The Applied Educational Research and Evaluation Seminar dealt with the techniques of asking a question pertinent to education and then conducting research to collect data to answer the question posed. In this study those techniques learned were used to answer the question: Is there a relationship between previous level science courses taken and scientific literacy?

PROCEDURES

Definition of Terms

Scientific Literacy - can best be defined as the level of understanding a person has of the facts of science. This includes an understanding of the process of collecting data, the building of models from which comes an understanding of nature, the self

correction of false conclusions, and the application of these concepts to everyday life.

Transfer student - student who will transfer to a four year institute.

Terminal student - student who will receive a two year degree and then seek employment

Limitations of the Study

This study was limited to the variables studied. The time passed from the student's science course work and the survey may affect the validity of the hypothesis. This limitation was taken into consideration when designing the survey instrument.

Assumptions

A number of assumptions were made regarding this research project.

1. The homogeneity of the groups was assumed with respect to a normal distribution of intelligence and equal opportunity to education.

2. It was assumed that previous college-level science courses would account for any differences between groups.

3. It was assumed that the sample population was a representative sample of Pima College students.

Designing the Survey

The survey (Appendix C) was designed to have three parts. Part one included survey questions selected from Miller's (1987) national survey. Permission to use Miller's questions was asked of the publisher (Miller, 1987). These questions were selected to gather opinions about certain topics in science. These questions were included to add clarity of understanding about the Pima College sample as compared to the national sample of Miller's (1987) survey.

Part two included questions designed to solicit the level of knowledge a person has about basic scientific facts and the application of those facts. Twelve questions were designed to meet the above criteria. The twelve questions where then mailed to five experts. This group of experts included a research astronomer (Rieke, University of Arizona), a professor of statistics (Crowley, professor emeritus Fordham University), a professor of physics/biophysics (Marlowe, Miami-Dade Community College), a professor of science methodology for elementary school teachers (Horak, University of Arizona) and a professor of physical science (Peterson, Rhode Island College). Each expert received the twelve questions and a Likart type scale for each question. The questions were then rated by the experts (Appendix A).

The returned ratings were averaged for each of the

twelve questions. All questions which averaged three or above on the Likart type scale were used in the final survey. Some experts included comments which were incorporated into the final survey. The experts' responses are found in Appendix B.

Part three of the survey included demographic questions. These data were used to compare the population of the survey takers to the general population of Pima College students. This was done to insure that a representative sample was used.

Validating the Survey

A field test of the completed survey was given to several students representative of the population in the survey (Isaac, 1987). These students were told that they would be taking a science survey which would be used to measure their knowledge about science. They were also informed that the survey would be used to gather their opinions regarding certain scientific statements. It was found that most students completed the survey in seven minutes. All students were finished with the survey in ten minutes.

Following the survey, the students were questioned about it. When asked about the clarity of the questions used in the survey all agreed that the questions where clearly stated and understood. When asked about the content of the questions all agreed that the content was

consistent with the goals of the survey. When asked about the time needed to complete the survey all agreed the time spent on the survey was adequate.

Selection of the Population

A total of eighty nine currently enrolled students at Pima College participated in the science literacy survey. The students were selected from four classes. The classes included a second semester sociology class, a first semester astronomy class, a second semester spanish class and a first semester physics class. All students in these classes were enrolled at the East campus of Pima College. A demographic survey revealed that the students in the science survey population, in general, reflected the student population of Pima College (Table 1).

Table 1

Comparison of Survey Students to Pima College Students

	Survey Students	Pima College Student Population
Male	28.4%	46%
Female	70.5%	54%
American Indian	1.1%	2%
Black	4.5%	3%
Oriental	3.4%	3%
White	77.3%	72%
Other	13.6%	20%

It was shown from the demographic survey, based on private communication with a Pima College statistics professor (Alberding 1989), that the expense of doing a random selection from all currently enrolled students at Pima College would not have been justified. The random selection would not have produced any significantly different cross-section of the Pima College student population which would have affected the outcome of this survey The population of students who participated in this study were representative of the college's student population with regards to this study.

Although Table 1 shows a difference between sexes of survey students compared to the general Pima College population, this was not a concern. Based on a previous study (Iadevaia 1989) it was shown that the difference between male and female students' science scores at Pima College was not significant; therefore, the potential problem with more females represented was a mute point as far as this current study was concerned.

The survey was given to the population of students selected for the study during their regularly scheduled class time. The professor of the class administered the survey. All responses were made on a computer ready answer sheet.

Part two of the survey was machined scored. Part one and part three data along with the score from part two

were entered into the ABstat statistical package (ABstat 1987). The data was then analyzed and conclusions were drawn from it.

Treatment of Data

The data from the two groups extracted from the surveys, that is, those with previous college-level courses and those with previous high school level courses, were compared. A one tailed t test was used on the mean difference of the two groups. The null hypothesis, that there is no difference between the two groups, was tested. A significance level of 0.05 was used to test the critical t value for the purpose of accepting or rejecting the null hypothesis.

According to Issac (1987) the formula used to calculate the t value was

$$t = \frac{X_1 - X_2}{\sqrt{SE^2_{x1} + SE^2_{x2}}}$$

where: X_1 = the mean high course takers score

X_2 = the mean college course takers score

SE^2_{x1} = the standard error of the mean for X_1

SE^2X_2 = the standard error of the mean for X_2.

Null Hypothesis

There is no significant difference in the test scores on a science survey between students who have had prior college-level science courses and those who have had prior high school-level science courses.

Alternate Hypothesis

The alternate hypothesis for this study will be the following: There is a significant difference in the test scores on a science survey between students who have had prior college-level science courses and those who have had prior high school-level science courses.

RESULTS

A comparison of Miller's (1987) data regarding certain opinion statements to the Pima College population is displayed in Table 2.

Table 2

Miller's (1987) National Results vs. Pima College Survey Results about Opinions Expressed as A Percent Agreed with Statement

Question	Miller's National % All	F	M	HS	C	Pima College % All	F	M	HS	C
3	7	8	6	6	2	6	5	8	0	0
4	40	38	41	42	28	23	24	21	30	18
5	53	55	49	57	38	24	19	36	23	12
6	47	41	53	39	63	58	48	80	46	50
7	57	58	56	59	48	17	18	16	31	15
8	20	21	18	20	6	7	8	4	15	3

The abbreviations used in Table 2 are as follows, All is for all survey takers, F is for female, M is for male, HS is for high school science and C is for college science.

An simple analysis was done on the part two content questions. Table 3 displays the number wrong for each question on the survey (Appendix B) and the experts' average Likart type score for the question.

Table 3

Content Questions Item Analysis
vs. Experts' Ratings

Question	# not correct	%	Experts' Rating Mean	Rating %
1	20	22	3.8	76
2	3	3	4.6	92
3	49	55	4.0	80
4	25	28	3.8	76
5	29	33	3.6	72
6	28	31	3.8	76
7	59	66	3.6	72
8	68	76	4.6	92
9	22	25	4.6	92
10	19	21	4.0	80
11	56	63	3.6	72
12	64	72	3.5	70

For example, Table 3 shows that questions 2, 8 and 9 at the 92 percent rating and the survey takers scored 3 percent, 76 percent and 25 percent wrong on these questions. The questions which posed the greatest difficulty for the survey takers was the question about energy (Appendix C question number 16). The top six questions in order of apparent difficulty are displayed in Table 4.

Table 4

The Six Most Difficult Content Area Questions

Order of Difficulty	Question #	Topic	% Not Correct
1	8	Energy	76
2	12	Reaction Rate	72
3	7	Photosynthesis	66
4	11	Relativity	63
5	3	Projectile Motion	55
6	5	Plate tectonics	33

The scientific fact portion of the survey, part two, which was assigned a score based on the number correct responses is displayed by high school science course and college science course in Tables 5 and 6 respectively.

Table 5

Statistics of Survey Takers Who Had
High School Science Courses

Mean Score	SD	Standard Error of the Mean
7.07	1.90731	0.226356

The data for Table 5 and Table 6 were computed from the ABstat statistical package (ABstat 1987).

Table 6

Statistics of Survey Takers Who Had
College Science Courses

Mean Score	SD	Standard Error of the Mean
7.88	1.86677	0.324964

A calculation of a one tailed t test at the 0.05 level of significance on the means of the scores for the high school and college course takers was made. The calculated value was found to be 2.04 which exceeded the critical t value of 1.65 (Issac 1987). Table 7 displays the results of the analysis.

Table 7

Analysis of the Mean of
the Two Groups

$\underline{t}$ critical	$\underline{t}$ calculated	Reject H_o
1.65	2.04	Yes

From Table 7 it is seen that since the critical $\underline{t}$ value has been exceeded the null hypothesis was rejected. This was based on a significance level of 0.05.

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

The null hypothesis was rejected, that is, there is no significant difference in test scores on a science survey between students who have had prior college-level sciences courses and those who have had prior high school-level science courses. The alternate hypothesis, that is, there is a significant difference in the test scores on a science survey between students who have had prior college-level science courses and those who have had prior high school-level science courses, was accepted.

From the results, it is clear that Pima College students reflect the national findings. People with college experience in science tend to have a higher degree of scientific literacy than people with high school experience in science. The implication is clear that based on this study all college students should have science courses in order to raise their level of scientific literacy.

The data revealed a weakness in content about some important concepts in physical science. Specifically, it was found most survey takers could not successfully answer the energy question. These energy concepts are usually found in a basic physical science course (Hewitt 1989). As it turns out the six most difficult questions (Table 4) are addressed in a basic physical science course.

The data also revealed that Pima College survey takers accepted evolution more readily than did the national population. This can be seen in Table 2 which shows question 6 (Appendix C) is about evolution. It was found that 47 percent of the Pima College survey takers agreed with the statement that human beings as we know them today developed from earlier species of animals.

As with most college curricula one finds a shortage of time to include everything that is important to produce a literate person. However, during the first two years of higher education Pima College should structure its curricula to meet the needs of the transfer student as well as terminal program student. The student should be educated for life and not just a career.

When comparing the opinion questions, part one of the Pima College survey, clearly one can see a general trend to the national survey but it seems to be apparent that current enrolled science students tended to agree with the prevailing scientific opinion. However, this apparent agreement says nothing about the actual knowledge the survey takers had about content areas. Miller's statement about the difference between having an opinion about something verses knowledge about that something has had light shed on it. It seems to have been upheld by this study.

It is recommended that all Pima College students have

as a minimum one physical science course. Such a course is already in the college course bank. It is Physical Science 115 (PHY 115). This course meets the general education requirements at Pima College and transfers to the University system. If all students take this course, non-science as well as vocational, it should make a difference in their understanding of the world in which they live. This conclusion seems to be supported by this study and Miller's study. These students will be more scientifically literate.

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APPENDIX A

Letter and Survey Content Questions Mailed to the Experts

Prof. David G. Iadevaia
2602 W. Prato Way
Tucson, Arizona

Dear Colleague:

Enclosed please find a number of questions. These questions will be used in a survey to measure, in a general way, scientific literacy and attitude about science.

I need your input regarding the appropriateness of the questions selected for the literacy portion of the survey. Please be so kind as to rate the questions according to the following scale.

1	2	3	4	5
Not Appropriate		Marginally Appropriate		Appropriate

I have enclosed a sheet for you to use to mark your responses. Feel free to include any comments or questions you would like to see in this survey.

Your comments must be returned to me by 22 Sept. 1989. Please use the stamped self-addressed envelope provided. It is only necessary to return the response sheet. You may keep the questions.

Thank you for your time.

Sincerely,

David G. Iadevaia

RESPONSE

	Not Appropriate		Marginally Appropriate		Appropriate
1.	1	2	3	4	5
2.	1	2	3	4	5
3.	1	2	3	4	5
4.	1	2	3	4	5
5.	1	2	3	4	5
6.	1	2	3	4	5
7.	1	2	3	4	5
8.	1	2	3	4	5
9.	1	2	3	4	5
10.	1	2	3	4	5
11.	1	2	3	4	5
12.	1	2	3	4	5

Evaluator's Name: _____

Title: _____

Institution: _____

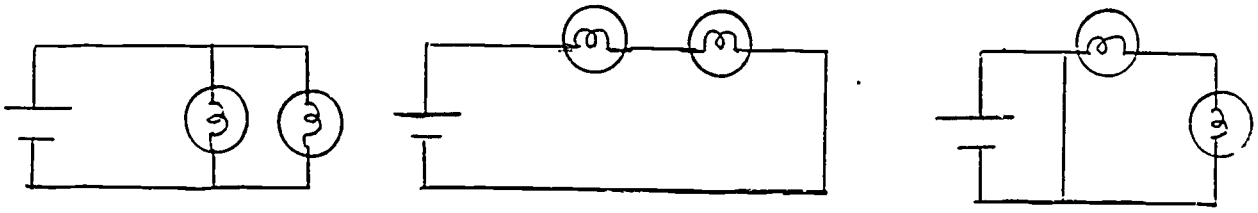
Address: _____

_____

Phone: _____

Comments:

General Scientific Literacy Questions



Circuit A Circuit B Circuit C

1. In which circuit above will one light remain lit if one light burnt out?

   A. Circuit A

   B. Circuit B

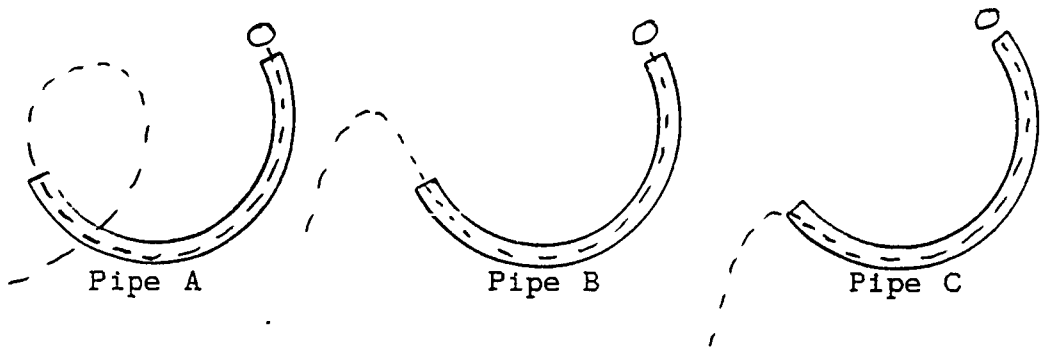
   C. Circuit C

2. A person is standing outside and sees a flash of lightning. Three seconds passes and the person hears thunder. What can you conclude from this?

   A. Light and sound travel at about the same speed.

   B. Light travels faster than sound.

   C. Light travels slower than sound.



3. As seen above, a ball rolls down a curved pipe fast enough to be ejected. Select the drawing which best describes the ball's motion after leaving the pipe.

   A. Pipe A

   B. Pipe B

   C. Pipe C

4. The star closest to the Earth is called:

   A. Alpha Centauri

   B. Sun

   C. Proxima Centauri

5. If a person was to place a maker somewhere on the Atlantic Ocean coast in North America and a similar mark somewhere on the Atlantic Coast of Africa and very accurately measured the distance between these two markers, over time, the distance between these markers would:

   A. increase

   B. decrease

   C. stay the same

6. If electrons exist as particles then they are _____ atoms.

   A. larger than

   B. the same size as

   C. smaller than

7. A person is in the hospital with an illness. To get well the person requires the maximum available oxygen in the room without oxygen tanks or tents. Her friends have sent many green, leafy plants which are in the person's room. When should the plants be removed from the room?

   A. At night.

   B. During the day.

   C. It does not matter.

8. A source of fuel has 100 energy units. A machine uses this fuel. The work done by the machine, using this fuel is:

   A. Equal to 100 energy units.

   B. More than 100 energy units.

   C. Less than 100 energy units.

9. The seasons of Earth, Fall, Winter, Spring and Summer occur mainly because:

   A. of the changing Earth/Sun distance.

   B. of the tilt of the Earth's spin axis.

   C. of the relationship of the Earth/Moon orbit.

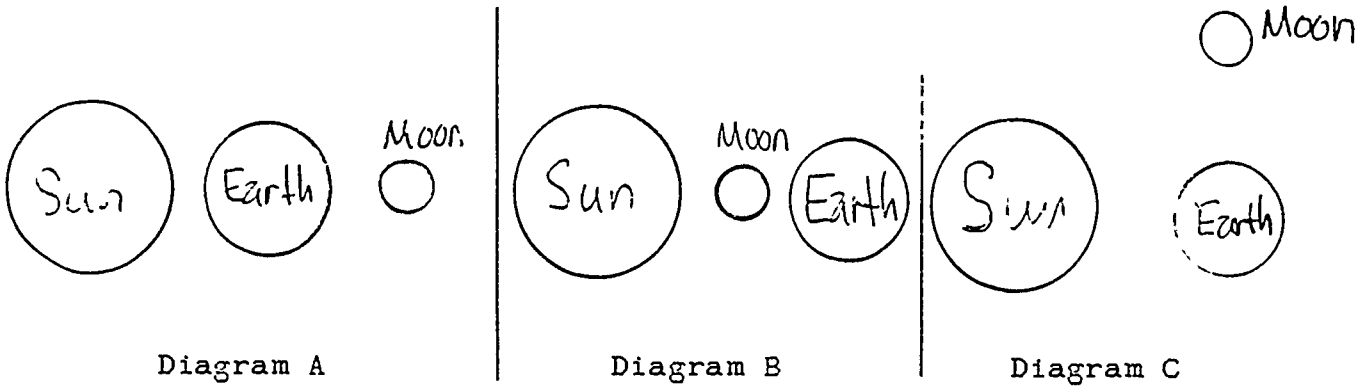


Diagram A | Diagram B | Diagram C

10. Which diagram above best illustrates a possible solar eclipse?

    A. Diagram A

    B. Diagram B

    C. Diagram C

11. You have two identical clocks. Both keep the exact same time. Clock B is sent into space at the fastest possible speed. Clock A is left on Earth. Which clock will tick at a slower rate?

    A. Clock A

    B. Clock B

    C. Clock A and B keep the same time because they are identical.

12. A person mixes two clear solutions and a clear solution results. After ten seconds the clear solution turns blue. To increase the time it takes the clear solution to turn blue, in general the person could:

    A. increase the temperature of the solution.

    B. decrease the temperature of the solution.

    C. keep the temperature of the solution constant.

APPENDIX B

Experts' Evaluation of Survey Content Questions

RESPONSE

	Not Appropriate		Marginally Appropriate		Appropriate	
1.	1		2	3	4	(5)
2.	1		2	3	4	(5)
3.	1		2	3	4	(5)
4.	1		2	3	4	(5)
5.	1		2	3	4	(5) Typo
6.	1		2	3	4	(5) All right
7.	1		2	3	4	(5)
8.	1		2	3	4	(5)
9.	1		2	3	4	(5)
10.	1		2	3	4	(5)
11.	1		2	3	4	(5)
12.	1		2	3	4	5

Evaluator's Name: Francis J. Crowley

Title: Professor (Retired)

Institution: Fordham Univ.

Address: 2609 Alice Way

Pinole CA 94564

Phone: (415) 741-8391

Is question 12 keyed correctly? I had thought that generally an increase in temperature speeds up the reaction and thus reduces time. If I'm wrong it must be a poor question. It certainly couldn't be my inadequacy.

Generally, I'd suggest dropping a few of the physics questions and adding a few bio (immunology, nutrition, metabolism and chem (solubility, oxidation) questions. Ask a bio and chem person. "Two most important principles that everyone should know."

Looks good.

RESPONSE

	Not Appropriate	Marginally Appropriate		Appropriate	
1.	1	2	(3)	4	5
2.	1	2	3	(4)	5
3.	1	(2)	3	4	5
4.	(1)	2	3	4	5
5.	1	(2)	3	4	5
6.	(1)	2	3	4	5
7.	(1)	2	3	4	5
8.	1	2	(3)	4	5
9.	1	2	3	(4)	5
10.	1	(2)	3	4	5
11.	(1)	2	3	4	5
12.	1	2	(3)	4	5

Evaluator's Name: Willis Hoak

Title: Associate Professor

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Address: College of Education, Room 321
Tucson, AZ

Phone: H 297-0601 Off. 621-1948

Comments:

Comments: I liked items which could be based upon experience. #7 seems that way but is entirely unrealistic (This would never make a difference due to air movement, etc.) Your results should be interesting. Sorry I'm late.

RESPONSE

	Not Appropriate		Marginally Appropriate		Appropriate
1.	1	2	3	4	(5)
2.	1	2	3	(4)	5
3.	1	2	3	(4)	5
4.	1	2	3	4	(5)
5.	1	2	(3)	4	5
6.	1	2	3	4	(5)
7.	1	2	3	(4)	5
8.	1	2	3	4	(5)
9.	1	2	3	4	(5)
10.	1	2	3	(4)	5
11.	1	2	(3)	4	5
12.	1	2	(3)	4	5

Evaluator's Name: JOHN E. PETERSON

Title: PROFESSOR OF PHYSICS AND ASTRONOMY

Institution: R.I. COLLEGE

Address: PROVIDENCE, R.I.

Phone: 401-456-9638

Comments:

RESPONSE

	Not Appropriate	Marginally Appropriate		Appropriate	
1.	1	2	3	4	(5)
2.	1	2	3	4	(5)
3.	1	2	3	4	(5)
4.	1	2	3	4	(5)
5.	1	2	3	4	(5)
6.	1	2	3	4	(5)
7.	1	2	3	4	(5)
8.	1	2	3	4	(5)
9.	1	2	3	4	(5)
10.	1	2	3	4	(5)
11.	1	2	3	4	(5)
12.	1	2	3	4	(5)

Evaluator's Name: JAMIE MARLOWE

Title: PROF. RADIATION PHYSICS/BIOLOGY

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MIAMI, FL. 33127

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Comments:

RESPONSE

	Not Appropriate	Marginally Appropriate		Appropriate	
1.	1	2	3	(4)	5
2.	1	2	3	4	(5)
3.	1	2	3	(4)	5
4.	1	2	(3)	4	5
5.	1	(2)	(3)	4	5
6.	1	2	(3)	4	5
7.	1	2	(3)	4	5
8.	1	2	3	4	(5)
9.	1	2	3	(4)	5
10.	1	2	3	(4)	5
11.	1	2	3	(4)	5
12.	1	2	(3)	4	5

Evaluator's Name: Marcia Rieke

Title: Asso. Prof. of Astronomy

Institution: U. of Arizona

Address: Steward Obs.

Phone: 626-2731

Comments:

Sorry I'm so late!

APPENDIX C

Complete Survey Used in the Study

Science Survey Questionaire

Pima College - East Campus

By: Prof. D. G. Iadevaia
October 1989

Use the SCANTRON sheet to record your answers
Use a #2 pencil

PART I

1. How well do you understand DNA?

   A. clear understanding

   B. general sense

   C. little understanding

2. How well do you understand radiation?

   A. clear understanding

   B. general sense

   C. little understanding

3. Do you ever change your plans due to astrology reports?

   A. Yes

   B. No

4. Some numbers are especially lucky for people.

   A. agree

   B. not sure

   C. disagree

5. Because of their knowled[illegible] scientific researchers have a power that makes them da[illegible]gerous.

   A. agree

   B. not sure

   C. disagree

6. Human beings as we know them today developed from earlier species of animals.

   A. agree

   B. nor sure

   C. disagree

7. In this complicated world of ours, the only way we can know what is going on is to rely on leaders and experts who can be trusted.

   A. agree

   B. not sure

   C. disagree

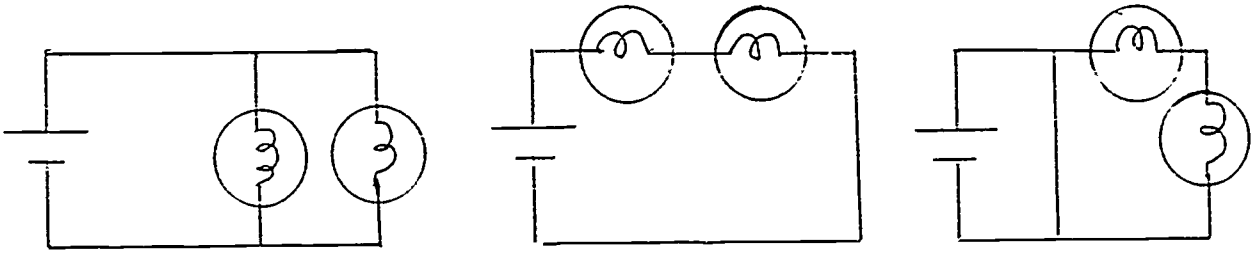
8. It is not wise to plan ahead because many things turn out to be a matter of good or bad luck anyway.

   A. agree

   B. not sure

   C. disagree

PART II



Circuit A Circuit B Circuit C

9. In which circuit above will one light remain lit if one light burnt out?

   A. Circuit A

   B. Circuit B

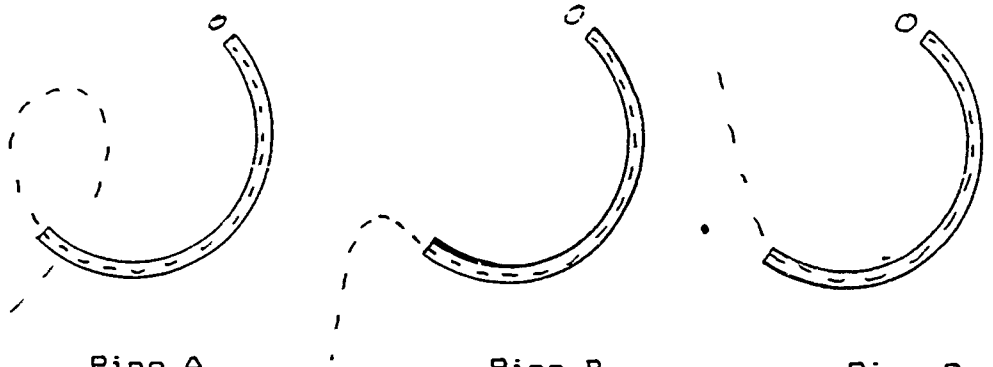
   C. Circuit C

10. A person is standing outside and sees a flash of lightning. Three seconds passes and the person hears thunder. What can you conclude from this?

   A. Light and sound travel at about the same speed.

   B. Light travels faster than sound.

   C. Light travels slower than sound.



Pipe A Pipe B Pipe C

11. As seen above, a ball rolls down a curved pipe fast enough to be ejected. Select the drawing which best describes the ball's motion after leaving the pipe.

    A. Pipe A

    B. Pipe B

    C. Pipe C

12. The star closest to the Earth is called:

    A. Alpha Centauri

    B. Sun

    C. Proxima Centauri

13. If a person was to place a marker somewhere on the Atlantic coast in North America and a similar mark somewhere on the Atlantic Coast of Africa and very accurately measured the distance between these two markers, over time, the distance between these markers would:

    A. change

    B. stay the same

    C. not sure

14. If electrons exist as particles then the size of the electrons compared to the size of the atom is

    A. larger

    B. the same

    C. smaller

15. A person is in the hospital with an illness. To get well the person requires the maximum available oxygen in the room without oxygen tanks or tents. Her friends have sent many green, leafy plants which are in the person's room. When should the plants be removed from the room?

A. At night.

B. During the day.

C. It does not matter.

16. A source of fuel has 100 energy units. A machine uses this fuel. The work done by the machine, using this fuel is:

A. Equal to 100 energy units.

B. More than 100 energy units.

C. Less than 100 energy units.

17. The seasons of Earth, Fall, Winter, Spring and Summer occur mainly because:

A. of the changing Earth/Sun distance.

B. of the tilt of the Earth's spin axis.

C. of the relationship of the Earth/Moon orbit.

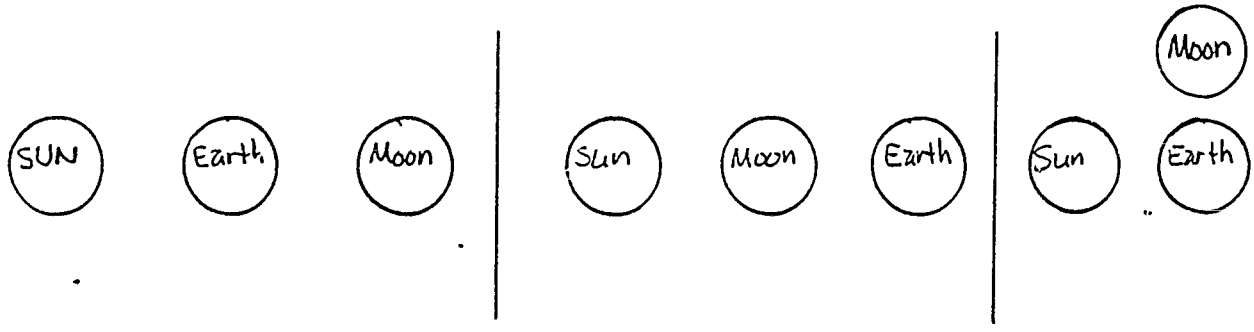


Diagram A Diagram B Diagram C

18. Which diagram above best illustrates a possible solar eclipse?

A. Diagram A

B. Diagram B

C. Diagram C

19. You have two identical clocks. Both keep the exact same time. Clock B is sent into space at the fastest possible speed. Clock A is left on Earth. Which clock will tick at a slower rate?

A. Clock A

B. Clock B

C. Clock A and B keep the same time because they are identical.

20. A person mixes two clear solutions and a clear solution results. After ten seconds the clear solution turns blue. To increase the time it takes the clear solution to turn blue, in general the person could:

A. increase the temperature of the solution.

B. decrease the temperature of the solution.

C. keep the temperature of the solution constant.

PART III

21. I am a :

A. male

B. female

22. My current age in years is :

A. 16 - 20

B. 21 - 25

C. 26 - 30

D. 31 - 35

E. 36 +

23. I am :

A. Married

B. Single

C. Divorced

D. Widowed

24. My race is :

A. American Indian

B. Black

C. Oriental

D. White

E. Other

25. How many science courses did you have in high school?

A. none

B. one

C. more than one

26. How many science courses did you have in college? Please include in your total any courses in which you are currently enrolled.

A. none

B. one

C. more than one