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SCIENCE ANXIETY: HOW CAN WE REDUCE IT?

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Science anxiety is a new name for a phenomenon that all science teachers, regardless of experience, are familiar with. Science anxiety is a fear that many bright and capable students have of scientific studies. This fear carries with it a conviction that they cannot, regardless of effort, understand science. Science anxiety is a very effective sieve that keeps many talented people from careers in science. Those science anxious students who enter teaching act as carriers of the anxiety, thereby infecting their students. Finally, science anxious students become members of our community and contribute to the growing climate of antiscience attitudes permeating our society today.

Science anxiety has many characteristics, of which most science teachers are painfully aware. Clutching on science tests, math anxiety, dislike for laboratory exercises, dislike of inquiry teaching are some of the more common characteristics of science anxious students.

What can we as science teachers do to reduce science anxiety in our students? The term "science anxiety" was coined by Dr. Jeffry Mallow, who has led the development of a desensitizing clinic program at Loyola University in Chicago. This program helps science anxious college students become less anxious about science. (9)

Others have approached the problem by turning for help to Jean Piaget's theory of cognitive development. Jean Piaget, a Swiss developmental psychologist, studied the development of logical reasoning in children for more than 50 years. From his extensive research has come a theory of cognitive development.

Central to this theory is the concept that all children pass through four stages of cognitive growth. The first two stages, sensorimotor and pre-operational, are usually attained by children at the age of seven or eight years. The third and fourth stages are characterized by logical operations (reasoning patterns) and are called concrete and formal, respectively. Piaget found that most children were concrete between the ages of seven and 11 years and became formal between their 11th and 14th year. Most high school students, therefore, are either concrete or formal. Some research, however, does not support this age range, claiming that as many as 50 percent of college freshmen may not be formal (5). Table 1 describes these cognitive stages in more detail (11).

The passage from one cognitive stage to the next is determined by the four factors of maturation, physical experiences, social interaction and equilibration. Equilibration is the mental process of producing new logical operations by combining new experiences with prior logical operations. The process of equilibration occurs most effectively when the new experiences are not much different than the existing logical operations.

Table 1
Characteristics of Concrete and Formal Thinkers

Concrete thinkers can perform the following operations:	Formal thinkers can perform the following operations:
1. combining	1. hypothetical-deductive thinking
2. separating	2. propositional thinking
3. ordering	3. reflexive thinking (thinking about thinking)
4. seriating	4. synthesizing
5. multiplying	5. imagining
6. dividing	6. abstract (nonconcrete conceptual thinking)
7. substituting	7. understanding of probability
8. reversible thinking	8. questioning ethics and values
9. one-to-one correspondence	9. formulating of theories
10. analyzing	10. broadening of time concept to infinity
11. measuring	11. space, conception of the universe molecular space
12. classifying	

Using these ideas, some teachers are reported to have analyzed their science courses to determine which concepts were concrete and which were formal (2,4). They then determined the cognitive level of their students. These teachers were better able to present the concepts of their courses to help students more easily equilibrate the ideas and experiences presented. By having more successful equilibration experiences, the students' anxiety for science was reduced.

Dr. J. Dudley Herron reported several techniques that could be used by chemistry teachers to help non-formal students understand formal concepts (5). Techniques proposed by Dr. Herron included the use of models and films that show microscopic systems, and the use of the factor label method approach to problem solving. Dr. Herron's major contention was that students can be encouraged to develop formal thought if they are exposed to a classroom environment that encourages the student to think out the ideas presented and not just to memorize facts.

To effectively combat science anxiety in students, teachers need to have a method of measuring the level of science anxiety which can be given easily to a large number of students. To provide such a method, the author has rewritten and revalidated such an instrument. This instrument called the *Modified Science Anxiety Questionnaire (MSAQ)* is based on the *Science Anxiety Questionnaire (SAQ)* prepared by Dr. Rosemarie Alvaro as part of her doctoral research at Loyola University in Chicago (1). Dr. Alvaro's SAQ was developed and validated for use with college undergraduates while the MSAQ has been validated for students in grades 9 through 12.

The questionnaires, SAQ and MSAQ, are based on 44 statements that are written to elicit a response that is recorded on a five-part likert scale. The scale of responses ranges from "not at all" anxious to "very much" anxious. This scale is like the one used in the *Mathematics*

Anxiety Rating Scale (10). The 44 statements are paired into 22 parallel statements, one with a science reference and one without. Two examples of such paired statements from *MSAQ* are:

Studying for a unit test in American history class
 Studying for a unit test in science class

Weighing yourself on a scale in a doctor's office
 Using a triple beam balance to find the mass of an object.

The 44 statements are distributed throughout the questionnaire in a random manner. The major difference between the *SAQ* and the *MSAQ* is the wording of the 44 statements. The *SAQ* uses college course references while the *MSAQ* uses high school course references.

The *MSAQ* was validated by interviewing students using a semi-structured interview technique reported by Borg and Gall (3). Based on the interviews, 10 students were selected for each grade, 9 through 12, five of whom were judged as anxious towards science and five of whom were judged as non-anxious towards science. Thirty-nine of the 40 students selected took the *MSAQ*. A chi-square analysis was used to see if there was a dependent relationship between the students' scores on *MSAQ* and the determination by interview of their anxiety level towards science. Table 2 shows the two-by-two contingency table and

Table 2

		Interview	
		anxious	non-anxious
MSAQ	non-anxious	1	19
	anxious	15	4

df=1
 chi square = 19.1 (p < .001)

chi-square value for this validation. The Yates correction for continuity was used because of the expected small frequencies in some cells of the table.

It is hoped that by the use of the *Modified Science Anxiety Questionnaire* high school science teachers will be able to measure the level of science anxiety in their students and to measure the effect of methods they develop to reduce that anxiety. Copies of *MSAQ* and directions for scoring may be obtained by writing the author.

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Ground Rules for Laboratory Workers

1. When you don't know what you're doing, do it neatly.
2. Experiments must be reproducible. They should all fail in the same way.
3. First draw your curves, then plot your data.
4. Experience is directly proportional to the equipment ruined.
5. A record of data is essential. It indicates you have been working.
6. To study a subject best, understand it thoroughly before you start.
7. In case of doubt, make it sound convincing.
8. Do not belief in miracles, rely on them.
9. Teamwork is essential, it allows you to blame someone else.

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