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ABSTRACT

This paper focuses on science anxiety in undergraduate education and then reviews current theories on how to reduce science anxiety. The exploration of the phenomenon of science anxiety points out that this response results not from a lack of self-confidence, but from a lack of a framework of prior knowledge to help order new knowledge; it also indicates that societal, educational and family attitudes convey habits of anxiety and that notions of science aptitude are inherited rather than learned. A discussion of methods to overcome science anxiety touches on relaxation techniques, concept mapping, the importance of prior science skill training, cognitive development from concrete to abstract reasoning, and student collaboration in curriculum development. The paper's central section reviews extensive research on sex differences in science anxiety, focusing on high levels of female science anxiety and science avoidance. A discussion on motivating students describes barriers to motivation and methods for modifying instructional methods to engage students more effectively including a brief description of how to use computer programs to increase the number of ways the student can approach the material. (Contains 14 references.) (JB)

SCIENCE ANXIETY IN OUR COLLEGES: ORIGINS,

IMPLICATIONS, AND CURES

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Preface

At the Corbin Center of Eastern Kentucky University, a new approach is being used to teach human anatomy based on current theory and research of educational practice. This paper focuses on science anxiety and then reviews current theories of how to reduce science anxiety. It is dedicated to Dr. Shelia Tobias and her theory of how the second tier student can be motivated through providing multiple approaches to the material. At Eastern Kentucky University, through the use of laser disks, hyper cards, cassette tapes and video tapes, the second tier student, as defined by Dr. Tobias, benefits from this approach.

The fear of learning science affects large numbers of people. Avoidance of science results in a scientifically uneducated citizen that cannot make technically based political decisions on issues such as nuclear energy and atmospheric pollution because it lacks the rudimentary tools to grasp the various arguments.

Students who have science anxiety may be doing well in all their other courses, even math, but are so anxious about one or more science courses that they are unable to function effectively in them. This difficulty in concentrating on course material eventually results in panic on exams and subsequent poor performance.

What Causes Science Anxiety

Anxiety results not from a lack of self confidence, but from a lack of a framework of prior knowledge to help order new knowledge (Worthy).

At the University of Chicago, writer/educator Sheila Tobias had Hellmut Fritzche, physics chairman, present physics classes to professors in non-scientific fields. The 30 scholars who took part were a mature, intelligent group, who, just the same, suffered from science anxiety (Worthy).

What was understood was interesting, but when understanding lagged, "mind block" set in.

A frequent complaint was of being left behind with no way to slow down the train. The instructor wanted to get on and cover all the material, but to the students complete coverage wasn't so important as complete understanding of what was covered (Worthy).

Science Anxiety and Science Learning

Investigations into the nature of good science teaching have taken two important directions. The first is the application of Piaget's theory to science learning and the second is the study of the emotional component in science learning (Mallow).

It is generally accepted that there is an optimal level of anxiety for performance. In the case of students studying science they are often so anxious it hinders performance.

Parents who say "I never was very good at science" convey the message that it is a heredity phenomenon rather than mastery of a body of knowledge and a set of skills (Mallow).

Students, when asked to invoke images or thoughts connected with feelings of science anxiety, frequently state memories of painful or humiliating experiences in classrooms. Teachers who use ridicule erode self esteem of students and this contributes to science anxiety of students.

Another cause is the teacher who pretends to effortlessly and without frustration understand the most difficult concepts. Such representation distorts the truth and reinforces struggling students' predictions to believe that they just don't have "scientific minds" thus their efforts are in vain (Mallow). It may be less malevolent but it contributes to underlying causes of science anxiety.

Other causes that contributes to science anxiety are they cannot believe the models and therefore cannot solve the problem. Part of the task of the instructor is to help the student feel comfortable with the models of nature, while keeping in mind that they are only models (Mallow).

Systematic desensitization is based on the principle that two incompatible responses e.g. relaxation and anxiety cannot coexist. One will suppress the other. Therefore the first step in systematic desensitization is relaxation training. Thus the student becomes desensitized to anxiety arousing situations as the relaxation response replaces the anxious response (Mallow).

How to Overcome Science Anxiety

Coping strategies are taught students so they say, "These problems are tough, I'll look back to the sample problem in the text and see how it was done" or "I'll see the instructor about getting some help on these problems" or "It's going to be hard work to do well in physics, but I intend to use every resource I can." As a result, students are able to focus on the task of learning science. Students thus perceive the effect of their thinking on their feelings and substitute objective thoughts for distracting ones that cause anxiety (Greenburg & Mallow).

The study also used relaxation techniques by Meichenbaun (1977) using imagery. The students are asked to picture themselves in a very peaceful scene. They are guided into actually putting themselves into the scene using concrete sensory details. One example might be: **lying on the beach, looking at the water, hearing the sound of the waves, feeling the sand and wind, and smelling the sea air.** Whenever an event is anxiety producing, we ask the student to mentally return to their relaxed place. Using this technique, students are usually able to relax in a previously anxiety producing event (Greenburg & Mallow).

Science anxiety is widespread. Specific techniques are needed for learning science and these are different from those needed for learning other subjects.

To reduce science anxiety there is an obvious synergy between negative self-statements and the ability to master science-learning skills. The student who says "no matter how much I study, I'll never understand science" will be blocked from mastery of the concrete skills needed and will have created a self-fullfilling prophecy (Mallow, 1991).

An introductory foreign language course requires mastery of a 500 word vocabulary while an introductory course in biology requires the mastery of 900 new words. It is necessary to teach explicit science reading skills. By analyzing the structure and content of science materials you can tell how best to approach them (Mallow, 1991).

Popular Press Articles

These are the easiest to read. They are written in journalistic prose in the active voice with plenty of quotes. The advantage is that there is communication in one fairly rapid reading. The student will learn the results but not the processes by which the research was carried out.

Popular Science Press

The readership is assumed to have more background in science and the science vocabulary use is more difficult than in the popular press. The consequence is the reader should expect to read the article more slowly than popular press article.

Original Research Articles

Although the article is obviously written for specialists, even the ordinary reader can learn a great deal from analyzing its structure. In particular one can gain a clearer view of what is actually involved in original research. In science, students often cannot make the distinction between what is known and what is specifically not known because they have never been taught how to read a science article and assess the content.

Science Textbooks

The procedure is the same as for research articles. The same scientists who write research articles used textbooks when they were students. Read slowly and read more than once with pencil and paper in hand chewing over each new idea. Ideally, read a chapter at least three times. First, before it is covered in class, second, while it is being covered, and third, after it has been covered.

Various features should be included to help measure comprehension so the students have a way of keeping track of their understanding. Students should be taught explicitly how best to use all text features (Mallow, 1991).

Concept Mapping to Reduce Science Anxiety

Metacognitive strategies have been shown to enhance learning in biology. Concept mapping is significantly more effective than traditional expository strategy in enhancing learning in biology. It also reduces students' anxiety toward mastering biology. It reduces anxiety more for males than females.

Research shows few students at even the college level have had any formal instruction on how to learn. Efforts in assisting the learner to learn has led to development of metacognitive strategies of learning about meaningful learning. Concept mapping strategy states that meaningful learning ensues when a learner is aware of and can control the cognitive processes associated with learning. Students are expected to arrange concepts in a hierarchal manner beginning with most abstract and ending with most concrete. Related concepts are linked by means of arrows and explanatory notes until a concept map is achieved with hierarchal relationships and meaningful linkages between concepts (Mallow, 1981).

New Cures for Science Anxiety

In an earlier article Mallow (1981) stated that science skills are frequently neglected in school. Skills necessary for learning science are quite different from those necessary for learning humanities.

Students in secondary schools and colleges take as little science as possible and almost invariably find their science courses stressful and unpleasant.

Women are particularly affected by science anxiety. Discriminatory ideas about the inability of women to excel in science foreclose to them a wide range of careers. While approaches are being made to communicate the excitement and creativity of science, it does not deal with the underlying anxiety.

People are not bored with science, they are frightened by it. In order not to be frightened by science they need to (1) develop science skills, (2) learn to reduce anxiety by mastering cognitive investigation skills, and (3) learn physiological techniques for reducing anxiety (Mallow, 1981).

First, the student needs science skill training. To learn science, the student must first acquire the basic skills of the discipline; how to read science material, how to take notes in a science lecture, how to approach word problems, how to function in the laboratory, and how to prepare for and take science exams. Second, they need to uncover the cognitive roots of their anxieties, i.e. the way they build up fears in their own minds. For example, while taking a test students monitor their feelings and identify negative reactions. Then using the cognitive restructuring approach developed by Albert Ellis, they examine these negative messages. They find the irrational components and learn to substitute appropriate coping messages. For example, an irrational component would be the student "if I can't pass this simple quiz, I'll never get in a professional school." The objective coping message is one exam does not determine your future focus on the task. Take one step at a time. Third, the student learns physiological techniques such as deep muscle relaxation developed by E. Jacobson and systematic desensitization developed by J. Wolpe which help to reduce general stress (Mallow, 1981).

After students master deep muscle relaxation, they then go through and develop a hierarchy of low to high anxiety producing items. For one person, looking through the test may be a low anxiety item, while working on a problem on an exam would cause greater anxiety. The student has to learn to try to relax while visualizing the anxiety situation (Mallow, 1981). The combination of cognitive restructuring and systematic desensitization is a very effective means of reducing science anxiety.

Science educators must be aware of the natural transition of their students from concrete to abstract reasoning as defined by Piaget. Students need to learn from concrete science experiences before they move in too quickly to concept generalizations and abstract problem solving. While students move at different rates through these stages, science courses can be designed to aid the transition by beginning with simple hands-on activities in early stages which allows students' natural instincts for inquire to lead them to concept understanding (Mallow, 1981).

Any course that emphasize student involvement through investigation would be effective to move students from informal to formal reasoning.

The Effects of Attitudes, Abilities, and Anxiety

Perceptions Toward Science

Females are more anxious about studying science than males at every grade level. New evidence is emerging that suggests a relationship between factors of reduced time allocated for science instructors, fewer women enrolled in science classes, and negative student attitudes toward science increasing by grade level and the existence of science anxiety (Chiarelott).

Mallow (1981) in his book, Science Anxiety: Fear of Science and How to Overcome it, implied that this fear could result in students becoming frustrated, denying competence in science, and ultimately disliking and avoiding anything scientific. He particularly noted science anxiety was being reflected in lower achievement scores (Chiarelott).

Studies indicate that females did as well as males in science in primary grades, but fell behind males in high school. Males tend to have greater numerical and spatial ability (Chiarelott). Matyas (1985) noted that females had more negative attitudes toward science, and these negative attitudes affected career choices. Yager and Yager (1985) noted that few third graders (5%) felt that science was boring while by the seventh grade 25% felt that way and in eleventh grade 33% felt that science was boring. They also noted that in the third grade 50% of students felt they were no longer interested in studying science.

When compared with other females, fourth-grade females are significantly more anxious than female students at other grade levels. This differs from other studies that suggest science anxiety increased by grade level. For females, it appears that the sixth grade is the least anxious period. This may be explained by the fact that in the sixth grade females are scoring nearly as well on CTBS science tests as male counterparts (Chiarelott).

The assumption that higher anxiety and lower achievement are linked was shown clearly in this study. However, merely lowering anxiety levels may not result in increased science achievement scores. What is needed is efforts to lower levels of science anxiety combined with improved instructional learning experiences. Based on this study, high enough levels of science anxiety exist in high achievers to suggest that some of the better students do not particularly enjoy science (Chiarelott). The link between achievement, attitudes, and anxiety needs to be understood before any qualitative change in curriculum content or instructional process will be effective.

During the last ten years increasing number of women have chosen to pursue graduate science and engineering degrees. However, the science attrition rate for both undergraduate and graduate women continue to be greater than men (Matyas).

Matyas' study seems to address a wide range of factors that are relevant, but many times are not seen as being relevant either to the instructor or the student. Factors such as locus of control, cognitive style, participation in science activities, self estimate of ability and attitudes of women toward women in science may be an important part of the answer of how to motivate female students and reduce their higher than average science attrition rate (Matyas).

If you praise them, students who have an internal locus of control do better in school. However, if they have an external locus of control, it would be to the student's benefit to at least try to provide plenty of experience that what they do matters. To explain to them the benefits of an internal locus of control, that progress will be a positive upward cycle if each time they succeed they work that much harder to succeed again.

The way women assimilate knowledge may be different than the way men do. Women are more emotional and are very sensitive to an instructor's perception of the female student's ability and particularly if the instructor perceives a female to not be as able as a male student. In a sense, this becomes self fulfilling because the female student soon says "what's the use." If the female student had an internal locus of control then this would not be as important a factor. But with an external locus of control it becomes devastating. Combine this with peer pressure of wanting to be accepted by friends and not being different from them, a female with an external locus of control would have no reason to ever excel in an adverse environment.

And an adverse environment when it occurs would effectively block the students path to the next step on the science track.

Matyas's study (1984) was compared to a similar one in 1976-77. In 1984 over 70% of secondary students were interested in science careers compared to 40% in 1976 (Matyas). This shows how important it is to understand the factors that enable more students to achieve success in science by achieving a goal that is relevant to them and is an intrinsic goal.

A comparison was also done between rural and urban environments. Students from urban schools generally had the most positive attitudes toward science and scientists. An urban school in Colorado had the highest scores on measures of spatial ability, feelings about science classes, participation in curricular science activities, willingness to fund scientific research projects and parental educational levels. This school also had the lowest scores on science and non-science test anxiety levels (Matyas).

More parents need to be involved in schools in stressing the importance of developing a high level of skill in spatial ability. Students need increased opportunities to participate and have specifically explained to them the relationship between participating in science focal and curricular science activities as being a very important factor in a student staying on the science tract. It helps a student maintain a high level of confidence in his/her ability to master science and overcome obstacles. (A second place at the state science fair and the offer of a partial scholarship meant a lot to one of the authors). You must first visualize achieving a goal before you can achieve it. This can only occur if you have several opportunities to achieve several successes that give you a solid basis to have self confidence.

In Matyas' study the main effect of gender was significant for six variables. "Females expressed greater science study test anxiety and observer anxiety, less confidence in their scientific and problem solving abilities, and less frequent participation in curricular and extracurricular science activities." However, the reverse might occur if they reversed their approach to science and they started to participate more in extra curricular activities and then made a special effort to do more problem solving so they could increase their ability and confidence at problem solving. This in turn would allow them to feel more confident and reduce their anxiety about science tests. Performance on any test is better if students approach it with confidence and analyze the problem calmly and rationally. The study also showed that greater contact with the academic counselor was negatively related to science career interest.

For males, positive attitudes toward women in science was the best predictor of science career interest.

In the discussion of other related findings it was noted that "Males have a greater tendency to have a field-independent mode of cognitive style" (Witkin & Goodenough, 1981), better spatial abilities (Maccoby & Jacklin, 1974), an internal locus of control (Lefcourt, 1976), and better science attitudes (Kahle & Lakes, 1983). However, they did not find gender differences on these variables to be significant. The teaching approach needs to be changed so that the attrition rate for women is at least no greater than that for men. Teachers need to remember that women were found to be more anxious about being observed while doing laboratory work. Females frequently express greater test anxiety than do males (Tobias, 1978), therefore teachers need to explain very clearly the material to be covered on a test. State as far in advance as possible the test date and the type of test. Give sample questions. State the number of questions and allow plenty of time for the students to take the test so that there are not more questions than students can answer in the time allowed. By being sensitive to the specific needs of female students you are providing an equal opportunity to succeed in science. For young women, feelings seem to play a larger role.

According to this study, when science classes make young women feel curious, confident, and successful, not "stupid" and afraid to ask questions, their career interests are correspondingly higher. If young women's positive feelings about science classes, women participation in science, problem solving abilities and achievement motivation can be fostered, then their achievement might not only equal but even exceed male achievement rates because these are very powerful forces (i.e. feelings) and since they more strongly affect females, and if directed toward success in a chosen field like science they could achieve higher success rates in science (Matyas). Women seem to learn better when they work together in small groups and relate what they study to their lives. This approach reflects the different ways boys and girls are socialized. Girls are raised to be a lot more group oriented, and they work best in cooperative ways.

Students as Collaborators in Development of Curriculum

Studies show that students play a key role in identifying problems stemming from lack of clarity both directions and questions. Problems in the sequencing of materials were often noted by the students earlier than by the teacher or other authors. Additionally, students were helpful in the identification and correction of format problems, usually dealing with placement of pictures and charts in relationship to questions and comments. Perhaps greatest contribution of the students involved the testing of the practicality of activities and experiments. The collaborative process between teachers and students in the development and revision of science curriculum materials tended to enable the development of higher quality materials that will require less revision at a later time (Liske).

Over the last fifty years the process of developing new science curriculum has evolved. Prior to the 1950's most schools curriculum was based on an adopted textbook. The textbook was usually written by one or two authors. In many cases the person was a scientist who knew much about science, but little about education or learning. This has been called "isolation curriculum development" (Liske).

In the late 1950's and 1960's 500 million dollars was spent in forming the "team approach" to develop new science curriculum. Writing teams now included educators, scientists, media specialist, artists, psychologists and practicing teachers. Two of the early products of this approach was PSSC and the Biology program. However, little improvement in academic ability in science could be supported, especially for the average and low ability student (Liske).

The first level of development (isolation development) involved little collaboration. The second level of development (Team Approach) was characterized by collaboration among those already educated. The third level of curriculum development involves collaboration between educators and students (Linske). This not to be exclusive. There is still value in team writing and trial testing. This can be incorporated with teacher-student collaboration.

Despite much progress in education, science teaching is still viewed "as deficient in purpose, scope, and style of teaching" (Hurd, 1986). An evaluation for the Michigan Science Teacher Association concluded the "basic problem is not with the top 25% of our high school graduates who understand and remember. It is with the 80% who simply memorize and quickly forget" (Liske).

The overall level of science achievement has declined compared to other countries (A Nation at Risk, 1983) and the proportion of low achieving students has increased. Many have at least average ability but poor motivation to learn science.

In the past, much energy has been spent on factors that are to a large extent out of the control of the educator. A survey of literature shows there were over 200 articles on low achieving science students which revealed a wide variety of factors over which the teacher has no control. Even factors like whether student was adopted were correlated with achievement rate in science (Liske).

In order to make significant gains in education you need to analyze the variety of impinging casual factors, divide them into controllable and uncontrollable factors, and focus on those that educational intervention will help. Research shows there is a strong correlation between achievement and motivation (Strivastovia, 1977; Vguragln & Walers, 1979; Napier & Riley, 1985). A study of the motives of individual students may help teachers understand low educational achievement and suggest profitable avenues toward high achievement in science education (Linske).

The most obvious weak area in a low achiever is weak metacognitive skills. Metacognitive skills involve task analysis, strategic planning, and performance monitoring. "The low achiever develops negative coping skills." In order to complete assignments the low achiever developed strategies that contribute to task completion, but did not necessarily contribute to the masterly of the content or acquisition learning to learn skills (Liske).

Other studies indicate that the majority of students procrastinate until the last moment to complete an assignment. In so doing they may indeed provide an excuse for not doing well but the emphasis should be on mastery of the material as the most important goal and not just the grade. Mastery learning must be stressed for the 30% low achievers.

Research has shown a high correlation between achievement and "locus of control." Achievement is associated with external locus of control. Achievement is associated with external locus of control. This occurs when students feel what they do personally has little affect on the outcome in their lives (Liske).

This shift of an internal locus of control to an external locus of control is hypothesis to occur as:

(1st) student experiences failure,

(2nd) a student in the face of failure has an "inherent need to establish and maintain a positive self-image and a sense of "worth", and

(3rd) the student then adopts a maladapted action. He adopts performance goals rather than learning goals (Liske).

Performance goals are motivated by the value judgement of peers and teachers. Students with performance goals exhibit greater anxiety toward tasks, avoid challenges, and show less ability to generalize and transfer of learning. In contrast children with learning goals see the long term benefit of the task and will complete the task for understanding and its own inherent value (Liske). Amers and Archer (1987) recognized "A performance goal orientation may actually provide a context that is not conducive to developing a positive achievement orientation and a longer term interest in learning" (Liske).

And yet instructors use no measuring technique to see if learning goals are being achieved on a continuing basis. The implication of research tends to indicate that learning goals are the only goals of value and a method of instructions is needed that allows for the student to ideally do as I am doing now and set in front of a fireplace and read and take time to just think and review material and take time to make sense of material and what the material means. They decide on how it fits with what they already know. They decide if it changes what they know or gives new insight. It takes time to reflect and use higher level thinking skills to interact with the material along with other material and see what it all means.

Various researchers indicate that students can be taught to attribute success to controllable causes (like effort) and are taught simultaneously specific strategies for coping with task motivation to learn can be increases (Liske). The profile of the low achiever is one of unclear goals, low self esteem, external locus of control, and weak metacognitive skills (and in some cases weak cognitive skills) (Liske). Repeated failure has ingrained a low expectancy for success and casual attribution to uncontrollable factors.

The instructor needs to be concerned with these aspects that are amenable to improvement through the educational system. Dweck (1986) points out that techniques that had success built into them may not work as intended. "Frequent praise and short, easy tasks do not create a desire for long challenging tasks, but may even reaffirm being 'dumb' and contribute to a further decline in performance. Failure to teach necessary high level skills may contribute to much low achievement."

Involving students in activity evaluation and planning helps build higher level thinking skills and helps build a sense of ownership in the endeavor and empowerment in the individual. Who knows better what and how the material is relevant to the lives of the students than the students themselves. This is the major factor for underachieving students. They do not see relevance.

Teachers should be using students to help create situations that communicate in a clear and relevant fashion. Too many times teachers have created a performance atmosphere in which they put students against students, and teachers against students. Johnson (1985) presents evidence that "in the generally competitive climate of most schools, success at academic tasks has little value to many students" (Liske)

Non verbal communication of teachers to student has an important affect. Studies show that teachers that ignore low achieving student questions and other negative teacher reactions to low achieving students actually become self-fulfilling prophecies. It becomes imperative the teacher recognize that students have valuable input. Their beliefs, attitudes, insights, and interests are important in learning and must be considered by teachers. Teachers must communicate a message that says "I believe in you."

Researchers realize that building a learning environment is a shared project. An ideal environment is one where the focus is on problem solving rather than evaluation, where competition is de-emphasized, where social comparison is discouraged, where ambiguity and error is accepted, and where responsibility is placed on the student (Liske). Students share in making education meaningful and successful. However, there is no suggestion that decision making is entirely turned over to students. In fact, Long (1981) claimed low ability students do worse with student managed curriculum and better with teacher managed instruction (Liske). Teachers play a critical role in organizing the learning process. Students play a critical role in furnishing input that makes the material relevant, workable, and interesting.

Motivating Students

Maintaining motivation is one of the greatest challenges for instructors engaged in teaching courses within the science curriculum. Another way of stating this is how do you "trick" students into being interested in the science. The student being interested in the subject is a prerequisite for any kind of learning. When a student is interested in the subject, he becomes self-motivated.

Dr. Tobias did a study in which she asked faculty and students about what made science hard (Tobias). Faculty felt that students who felt science was hard had inadequate preparation in high school. The faculty, in effect, focused the problem somewhere else. The faculty did not solve the problem by doing this. Dr. Tobias then proposed to create a study that would start with an ideal student body. In this case, faculty from other fields. They would write what they could or could not grasp. This ideal student body was an extremely able group. This process was repeated in many different fields of study. They would write a report which would serve to provide peer perspective in teaching.

When these ideal students were taking a science course, it was found that some of them felt lost because there was a lack of any framework presented within which to organize material. This then becomes a valid area in which improvement can be made when teaching a science course. One individual stated that when he did not understand immediately, he felt helpless. Good students try to make sense as they go along. Yet a physics instructor was so interested in completing a demonstration that he did not take any time for questions. The unspoken thought is that education was not the primary or even secondary goal. Instructors need to realize that time must be made available to allow students to construct knowledge so they make sense of the material as they go along. This means that instructors may have to reduce the amount of material that is covered in a course, but, for the student, he will gain a thorough understanding of the material and he will be able to develop insight into fundamental concepts that allow him to be a better prepared student than he would be otherwise. Failure to do this is probably why others of these ideal students stated "It was difficult to tell what was important and what was not", "It was hard to understand what was a fact and what was not." One faculty-student stood up and asked: "How do I know if I understand, how can I know what I do not understand?" (Tobias).

There is a problem with vertical subjects where a student will not understand a concept until he gets there, where one concept rests in another. But you should have a framework on which the student can construct the knowledge.

These ideal students noted other problems. Sometimes the course seemed endless. There did not seem to be a reason why the class moved from one concept to another. There was excessive problem solving. While they enjoyed problem solving, the larger issues were not considered (Tobias). bY relating the problems that are being solved to problems that the student will be faced with when he completes the program, the student then can see relevancy. The instructor who takes the time to develop an interchange of ideas creates a course that has more lasting value for the student. There should be the ability to interact. Courses should not seem to require an "obedience quotient". Students should feel as though they are constructing the knowledge as concepts are developed. "What", "why", and "how" questions should also be considered, not just "how much".

Teachers can direct students in what they will study through the questions that are asked on tests. Their grades are their paychecks. If you want students who understand broad concepts and see inter-relationships you must ask those kind of questions on tests. If they do not understand in depth the nature of the problem they solved, it makes the sciences seem intellectually unsatisfying (Tobias).

The best classes are when the student feels constantly intellectually engaged in constructing knowledge. When student opinions are not solicited and all that is requested is premasticated information, it makes for a difficult course to maintain the students' interest. Students should be encouraged to learn how to express themselves in class because if the student cannot make mistakes in the classroom, where can the student make mistakes while he is trying to construct knowledge.

Students should not be graded on the curve, because the curve turns classmates into enemies because the students then have every reason not to help each other. They need to interact among themselves trying to understand concepts. Share opinions and through discussion develop perspective through the interchange of ideas. In science the student should be told where they are going. Start with a simple foundation and build to a complex edifice (Tobias).

The "Fly Paper Theory of Learning" is "the more I know, the more that sticks." The task is to increase the surface area of the fly paper. If you increase the number of ways the students may approach the material the easier it is for the student to construct the knowledge. This may be done through having the material available on video tape, cassette tape, hyper card, and in the near future programs such as Podium (IBM) and Quicktime (MacIntosh) multimedia software programs (Tobias).

Instructors can make changes. It is possible to change the pace of the course. Change exams that are given so they include more open ended questions. change the grading system so it.is not a bell-shaped curve. A course should not be there to weed out students. Change the packaging of the course to allow for interaction of the students.

How to Motivate Learning With Multimedia

Multimedia, which creates the effect of combining a computer with a video camera, can be the best way to catch the interest of the unmotivated student. Multimedia can combine movies with narrative, it can show five frames of a movie, it can show three slides at the same time, all of which are preprogrammed through a computer software program.

There are several authoring software programs. Among these are: Podium by IBM for DOS or Windows; Quicktime by Macintosh; and Plus by Spinaker, which is a courseware authoring system with hypertext features that can be used on the Macintosh as well as IBM-PC Windows 3.0 compatibility.

Podium was designed to minimize the cost of initiating multimedia in the classroom. It requires only two megabytes of RAM and can be run on any computer with VGA graphics. Specifically, the recommended configuration is:

IBM PS/2 model 386 or 486 or compatible with mouse
Any Color VGA Monitor
IBM M-Motion Video Adapter (for micro channel architecture)
IBM Audio Capture and Playback Adapter (optional)
Pioneer or Sony Videodisc Flayer with RS-232 Interface
Compact Disc CD-ROM Drive (optional, with Microsoft CD-ROM extensions)
Overhead Projection Panel or RGB Projector
Audio Speaker System
Enclosure for Storing and Securing the Equipment

By using a configuration such as this, the instructor can roll the multimedia system into any classroom (Hofstetter).

More than a thousand videodiscs are catalogued in The Videodisc Compendium which is published by Emerging Technology Consultants, Customer Service Department, Post Office Box 12444, St. Paul, MN 55112 (Hofstetter).

It is also possible to produce your own videodisc. The slides and motion sequences have to be recorded onto one inch videotape. This may be done at the university T.V. studio. The tape would then need to be sent to a Pioneer, Em, or Phillips/DuPont Optical center offering videodisc pressing services (Hofstetter).

Quicktime, which has been developed by Macintosh, is a dynamic program which is similar to having a video camera on your Macintosh. It is a program which is provided free and is installed on your hard drive if you have a System 7 or the older versions System 6.07 or System 6.08. You also need to purchase Super Mac Video Spigot. This is a video board that allows you to record from a video camera, a video cassette recorder, and (with a special plug) from other video sources. At the present time it comes with Adobe Premier Software Program which allows you to edit, select images, and change position of images.

Quicktime is usually run on a Macintosh Quadra 700. It takes two megabytes to run the system. Once the material has been stored on the hard drive, it then can be displayed using full color overhead active matrix projection panels. These panels work with any overhead projector (Towslee).

Most recently an International Business Machines (IBM) Academic Information Systems initiative has resulted in the formation of a consortium of medical schools to plan, produce, and distribute interactive videodisc programs for medical and health sciences education (Rubeck, 1990). For example, a program called Thorax Plus was developed on an Apple Macintosh IIci in Spinnaker Plus, an object oriented hypermedia authoring language, with video material from the Slice of Life videodisc digitized with a Rastor Ops video digitizing board and text scanned in via an Apple Scanner and interpreted with OmniPage software (Rubeck, 1991).

The goal of multimedia is that instructors will find multimedia so easy to use that presenters will prefer it to overhead transparencies, 35mm slides, videotape, chalk, records, and audio tape recordings and that students will find it far more motivating than current education materials (Hofstetter).

This is the key in any course that I am involved with teaching. I will make sure that the students have access to material that they can review at their own pace, either through video taping human anatomy lab models or having the computer lab have the hypercard on human anatomy available to the student. This way the student can review the lab material even when the lab is closed by going to the library and making a copy of the videotape which explains the names of functions while they see actual lab models that will be used in the lab test.

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