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ABSTRACT

Community college students may be at-risk academically, socioeconomically, or because they are first-generation attendees. Recognizing the need for a strong support system, a study was conducted to determine whether students could be taught to incorporate information processing strategies into their personal inventory of strategies. It was anticipated that learning strategies within the context of a prerequisite course could improve academic performance and increase the incidence of critical thinking skills, thereby assisting students in the pursuit of a professional career or higher academic degree. In a one semester, quasi-experimental study, Human Anatomy and Physiology students were divided into control and experimental groups. The experimental group participated in the use of a student-generated questioning technique in conjunction with lecture presentations, while the control group did not. Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) revealed no significant differences with regard to overall achievement, the ability to process information, or the demonstration of critical thinking. Members of the experimental group did, however, exhibit a change in their ability to select main ideas, apply deductive reasoning, and use inference. (Author/SAH)

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Assisting At-Risk Community College Students= Acquisition of Critical Thinking Learning Strategies

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Assisting At-Risk Community College Students= Acquisition of Critical Thinking Learning Strategies

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Community college students may be at-risk academically, socioeconomically, or because they are first-generation attendees. Recognizing the need for a strong support system, a study was conducted to determine whether students could be taught to incorporate information processing strategies into their personal inventory of strategies. It was anticipated that learning strategies within the context of a prerequisite course could improve academic performance and increase the incidence of critical thinking skills, thereby assisting students in the pursuit of a professional career or higher academic degree. In a one semester,

quasi-experimental study, Human Anatomy and Physiology students were divided into control and experimental groups. The experimental group participated in the use of a student-generated questioning technique in conjunction with lecture presentations, while the control group did not. Pretests included the Learning and Study Strategies Inventory (LASSI) and the California Critical Thinking Skills Test (CCTST). Posttests included these same instruments and an end-of-course comprehensive examination. Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA) revealed no significant differences with regard to overall achievement, the ability to process information, or the demonstration of critical thinking. Members of the experimental group did, however, exhibit a change in their ability to select main ideas, apply deductive reasoning, and use inference.

Introduction

A community college is generally an open enrollment institution of higher education. This means that all students are welcome and admitted, regardless of their academic background. Most students expect that their experience at the college will allow them to (a) succeed in a career that would require the minimum preparation provided by an Associates Degree or, (b) transfer to a senior institution and pursue a higher degree. Instructors at community colleges therefore, try to teach students in such a way that despite their background they learn appropriate content knowledge as well as the skills necessary to continue their pursuit of a professional career or further education. If the intellectual skills can be acquired simultaneously with content knowledge, this would allow students to benefit intellectually and financially, and it would minimize the time that must be spent in taking additional preparatory classes.

Among community college students are many who enroll in pre-Allied Health classes with the intention of completing academic courses for medically-related careers they anticipate will be personally rewarding. And, if they successfully complete prerequisite courses they will be able to apply to a myriad of extremely competitive programs directed specifically at the clinical aspects of their chosen professions. Often, their primary expectation is that if they master the material by demonstrating a high end-of-course-grade and maintaining a high GPA (Grade Point Average), they will increase their chances of being accepted into a professional school. Unfortunately, although students may be able to master the "academic compliance" necessary to pass a course with good grades, they are not necessarily focused on thinking critically or independently (Johnson & Weaver, 1992). Testing programs together with The National Assessment of Educational Progress (NAEP, 1992) have indicated that the decade of the 1980's witnessed an improvement in the rate of knowledge acquisition by students. However, it has been shown that the acquisition and use by college students of "higher order" intellectual skills such as analyzing, synthesizing, applying, and problem solving are falling behind (Walberg, 1992). Because community colleges as open enrollment institutions work with large populations of nontraditional students, many of whom are at-risk academically, the importance of determining whether thinking skills can be specifically taught during the completion of introductory college courses is intensified.

Additional problems face students at community colleges. Due to open enrollment, the students are frequently considered to be "at-risk" from a variety of perspectives. According to criteria described by John Roueche, students may be at risk because many are first-generation attendees, economically insecure, familiar primarily with only their own neighborhoods, and academically weak (Roueche & Roueche, 1993). Other characteristics that tend to place community college students in a less than desirable climate for academic achievement include their need to work full or part time, care for a family while attending classes, and make allowance for study time necessary to be successful at the college level. Also, some may have completed only the minimal requirement of a Graduate Equivalency Diploma (GED) prior to beginning college and have experienced, at best, an incomplete formal secondary school education. The students are nontraditional in the sense that they do not fit the stereotypic profile of students who are younger, enter many universities having completed high school, are generally free of the obligation of familial dependents, and are perhaps equipped with more funding avenues.

Community college students who fit into any or all of the descriptions provided here may be considered at-risk, and effectively preparing the students for transition to the rigorous academic expectations of higher education or professional schools is, therefore, of high priority.

The important role that community colleges play in providing assistance for at-risk students is tied to their historical evolution. While early direction came from a goal to serve the educational and vocational needs of local communities, a more contemporary role sees the institution bridging a transfer gap in public education between secondary schools and institutes of higher learning (Ratcliff, 1994). The last three decades have added a sense of urgency to the role that community colleges should play in serving students in need of remediation (Spann & McCrimmon, 1994). Results of an extensive survey of community colleges that offer programs for at-risk students have included a strong recommendation that support and structure should be increased for these students, not only in basic skills training but in problem-solving activities as well (Roueche & Roueche, 1993).

Theoretical Bases

Prerequisite courses for Allied Health careers are taught at community colleges to large numbers of students, including many who might be classified as at-risk. Since college students pursuing Allied Health careers will be engaging in coursework and professional training beyond prerequisite courses completed at the Freshman and Sophomore college level, it is important to ascertain the effectiveness of teaching thinking skills at these initial levels of college instruction. Providing an opportunity during prerequisite courses at the community college level to learn strategies that enhance critical thinking may assist students by promoting early training in learning strategies needed for further academic pursuits.

While all students need "higher order" skills, they are particularly critical when dealing with students preparing for careers in Allied Health (such as nursing, physical therapy, and dental hygiene). It is expected that these individuals will have content knowledge as well as thinking skills in their academic "dossier" so that they can be further trained in independent decision making when they engage in clinical training (Alfaro-LeFevre, 1995). When instructions are given for patient care, the logic as well as details must be understood by the caregiver in order to insure the appropriateness and correct application of treatment. In fact, the National League for Nursing (NLN) established criteria in 1992 that are related to critical thinking and must be implemented in training programs that expect to attain accreditation by the NLN (Videbeck, 1997). Among the measures set forth by the National League of Nursing is "Required Outcome Criterion 1: Critical Thinking - This outcome reflects students' skills in reasoning, analysis, research, or decision making relevant to the discipline of nursing" (NLN, 1992, p. 26). Consequently, nursing programs must provide self-study documentation which includes a definition of critical thinking, rationale, assessment of methods used to measure or evaluate critical thinking, and a report of any outcome data with an indication of how the data are being used to develop, maintain, and revise programs (Videbeck, 1997). In their efforts to find an effective assessment tool to measure critical thinking skills, a number of institutions are using the California Critical Thinking Skills Test (CCST) which is based on a construct of critical thinking determined by the American Philosophical Association (Facione & Facione, 1994).

The expectations that have been set forth for professional programs also impact preprofessional educational programs at the community college. Many of the students enrolled in Human Anatomy and Physiology courses at community colleges are pursuing a career in an Allied Health field, with the exception of a few individuals who are taking prerequisites for work in Sociology or Social Work. Once they have completed their preliminary course work at the community college, application will be made to professional schools for degree completion. And, as they enter into institutions of higher education, it is expected that students will arrive with critical thinking skills that are appropriate for their career choices.

The term "critical thinking" has been described in many ways. For example, in her review of fifty-five self-studies in nursing, Videbeck (1997) identified ten different references that were cited as definition sources by faculty members completing the studies. While the faculty differed in their descriptions of critical thinking, what was agreed upon was that a definition of critical thinking includes both affective and cognitive abilities, with the latter being predominant. Critical thinking has also been called purposeful, reasoned, and directed thinking (Halpern, 1989) and has been used synonymously with terms or phrases such as problem solving, analysis, or analytical reasoning. Most definitions of critical thinking agree that thinkers would have the skills necessary to engage in analysis, comparison-contrast, evaluation, inference, and synthesis (King, 1994). Critical thinking skills are strategies used to find ways to reach a goal (Halpern, 1989), and further research has shown that students who lack a repertoire of cognitive skills cannot be self-directed and independent in their learning and performance tasks (Letteri, 1992). For purposes of the current study, critical thinking will be used synonymously with the terms "information processing" and "problem-solving" and will include synthesis, inference, analysis, comparison-contrast, and evaluation skills. These skills are also referred to as "cognitive" or "critical thinking" skills.

Success has been achieved in teaching thinking skills. Working with Biology students, Novak and Dettloff (1989) found that they were able to help students learn Atask analysis≡. Studies with nursing students who were preparing for clinical work indicated that the skills applied to the nursing-related content were effective

in developing critical thinking processes (Girod, 1994). When students in a critical thinking course were given insight into a metacognitive approach, they showed a significant gain in thinking skills and personal satisfaction (Hanley, 1995). Internalization and transfer of critical thinking skills has occurred following training in and practice of these intellectual skills (King, 1989, 1990, 1991, and 1992). Early studies by King compared college students' comprehension of lecture content when the lecture was followed by discussion, independent review sessions, guided self-questioning, or guided peer questioning (King, 1989). Students who participated in guided questioning methods, where they were taught to phrase questions based on question stems provided for their use, showed significant improvement over their peers. A comparison study of guided self-questioning, summarizing, and review of lecture notes as learning strategies in college students found that self-questioners performed significantly better than did other groups (King, 1992).

Were increases in comprehension due to the specific teaching occurring, or to the students' coincidental participation in a collegiate environment? Research has suggested that merely being involved in advanced education can alone produce more thinkers that think more critically, since a correlation has been found between increased critical thinking skills and number of college hours attained (Spaulding & Kleiner, 1992). However, other studies conducted by Stage (1989) showed that students with a lower GPA or IQ (Intelligence Quotient) scores were less likely to complete their college studies. Perhaps recognizing this trend, Marzano (1992) has suggested that it is very important that at-risk students be given specific instruction in critical thinking strategies because they frequently come from backgrounds that are not replete with all of the opportunities necessary for information processing. His premise stems from the observation that many middle and high achievers already possess thinking strategies that were obtained through interaction with information rich environments such as more reading in the home, family discussion of in-depth topics, and exposure to a "more complex information environment" (Marzano, 1992, p. 16). Similar opportunities may not have been available to students coming from informationally deficient or low socioeconomic backgrounds (Marzano, 1992).

While many techniques have been used successfully at senior institutions, they have not been employed at the community college level of instruction. Demonstration of successful techniques with at-risk students in prerequisite courses would make them an invaluable instructional tool. However, determination of an effective way to increase students' critical thinking skills is not a simple task. Ideally, one might suggest that it would be beneficial to introduce general, non-subject specific courses in critical thinking as prerequisite courses that students could take in order to prepare for future classes and employment. However, since many community college students are economically driven to complete academic requirements, they cannot necessarily afford additional time to take preparatory courses that are not absolute requirements for their major. Whether the thinking skills can be taught in the course of one semester so that students incorporate them into their own learning strategies for application in their study and career is seen as an important question by Weinstein (1994b). We are cautioned, however, that the relationship between critical thinking and success in college is complex and multi-faceted. More research is required in order to investigate other factors such as maturation, drop out rates of less capable students, and motivation that may have a bearing on student success (Spaulding & Kleiner, 1992).

Teaching learning skills or strategies cannot substitute for teaching domain-specific content, since one factor frequently relies on the other (Weinstein & Mayer, 1986). The learning strategies are techniques that are taught in order to be used during learning. They consist of behaviors as well as thoughts that are expected to influence the manner in which all information is encoded or processed by a learner. If the academic community embeds approaches to thinking within the instruction of content, we may be able to teach the approaches implicitly to students (Marzano, 1992). Resnick (1987) has found that this can be done by asking students to perform tasks that model specific types of thinking processes. Studies by Brown, Bransford, Ferrara, and Campione (as cited in Wittrock, 1986) suggested that when students become aware of the cognitive processes they are using, they are able to transfer them more readily to other areas of their learning. Self-reflection on one's own learning processes is a form of metacognition that can enhance an individual's conceptual changes (Wandersee, Mintzes, & Novak, 1994).

It is possible that there are circumstances in which some learners will not use strategies that may have enhanced learning for other individuals. As suggested by Garner (1990), these may include situations in which the individual does not recognize that learning is not occurring, may have a deficiency in knowledge base, or finds that use of a strategy does not assure successful performance. When examining application of

strategic learning it is important, therefore, to remain cognizant of the circumstances in which a learner is situated (Garner, 1990).

Exploring ways to improve students' ability to think critically is in step with the current reform movement in education. A constructivist philosophy forms a large part of the basis for the reform movement and fits well with the practice of critical thinking. Yager (Yager & Lutz, 1994) stated that in order to really learn, individuals need to actively construct meaning and they can do this by experiencing activities that challenge their interpretations or explanations. Directing the attention of students to deliberate questioning activities may result in forcing them to confront misconceptions with which they have grown comfortable so that in resolving their discrepancies, more meaningful learning may result. Questioning the "fit" between the world outside and inside their own minds could contribute to resolving another problem Yager discussed in science education, which is the fact that students do not see the relationship between science and their daily lives or potential careers.

Although individual processing is an important part of learning, Driver, Asoko, Leach, Mortimer, and Scott (1994) stress the value of discourse in learning about science concepts. As a learner meets new experiences and tries to make them meaningful, construction or reconstruction of ideas becomes important. And, because learning science is sometimes viewed as equivalent to embracing a new culture (Driver, et al., 1994; Aikenhead, 1996), encouraging students to critically view the concepts through social interaction may serve to make the transition into the culture easier, more personally rewarding, and durable.

Purpose

The question that needs to be addressed is: Can critical thinking skills be taught to community college students within the context of prerequisite courses so that students can be more effectively prepared for further professional academic pursuits? If information processing or critical thinking strategies can be taught and are incorporated into students' inventory of skills, they may be transferable to other classes and future learning experiences students encounter during their collegiate careers. The purpose of this research, therefore, was to determine whether the incidence of information processing skills in the at-risk community college students' inventory of information processing strategies could be improved within the context of a prerequisite course. If success was demonstrated, this could promote the use of similar techniques during preparatory course work at the level of community college instruction.

Definition of Terms

The following definitions of terms were used for the purpose of this study:

Critical thinking : Critical thinking is used synonymously with the terms information processing and problem-solving, and includes synthesis, inference, comparison-contrast, analysis, and evaluation skills, also referred to as cognitive skills or critical thinking skills.

At-risk students : At-risk community college students are nontraditional students who may be first-generation attendees, economically insecure, academically weak due to poor schooling, in need of full or part time work, are caring for a family while attending classes, or who may have completed only the minimal requirement of a GED prior to beginning college.

Learning strategies : Learning strategies are purposeful behaviors that are used by an individual to engage in the mental acquisition and integration of content and processes.

Research Question

The question addressed by the study was: Will the use of a guided student-generated questioning technique in Human Anatomy and Physiology lecture classes increase the academic performance and the incidence of critical thinking skills of community college students?

Three research hypotheses were proposed:

Ho₁: There will be no difference in the mean scores on an end-of-course examination given to students who use a student-generated questioning technique in Human Anatomy and Physiology lecture class compared with students who do not use the technique.

Ho₂: There will be no difference in the mean scores on the Information Processing Skills portion of the Learning and Study Strategies Inventory (LASSI) of students who use a student-generated questioning technique in Human Anatomy and Physiology lecture class compared with students who do not use the technique.

Ho₃: There will be no difference in the mean scores on the California Critical Thinking Skills Test (CCTST) of students who use a student-generated questioning technique in Human Anatomy and Physiology lecture classes compared with students who do not use the technique.

Sample

The population from which the sample for this study was drawn is a community college in central Texas with a total enrollment of 7,600 students. The ethnicity of the students at the college is 61% Hispanic, 33% Anglo, 4% African American, 1% Asian, and less than 1% Native American. The average age is 27, represented by 60% females and 40% males. Approximately 70% of the enrollment of the college includes individuals who are the first in their family to seek a college degree of any kind.

During each fall and spring semester, a total of 200 students are enrolled in the first semester of a two-semester course in Human Anatomy and Physiology. The students choose the course in order to fulfill one of the degree requirements for a number of Allied Health fields (such as nursing, physical therapy, and dental hygiene) or degree programs in Social Work or Sociology. Therefore, the majority of students in the class are Allied Health majors with a smaller number representing majors in Social Work or Sociology. The selection of a class section is based on students' personal choice of preferred instructor, day, and/or time of the class. Although students also enroll in a laboratory portion of the course, this study considered students' performance only in the lecture, but not the laboratory classes. This limitation was necessary because the laboratories were taught by a variety of instructors who were not participants in the study.

Four lecture class sections of the first semester class of Human Anatomy and Physiology with an expected enrollment of N = 100 students (25 students per class) were used for the study. Each class met during 50-minute classes held weekly on Monday, Wednesday, and Friday for one semester that was 15 weeks in length. Because the selection of students could not be controlled, the classes themselves were randomly

assigned to a combined treatment group (which contained two classes total) or a control group (which contained two classes total).

Of the students who were initially included in the study, $N = 49$ were in the control group. These students averaged 23.65 years of age, had earned a grade point average of 2.88, began the semester having completed 22.29 hours, and were enrolled in 12.27 semester hours at the beginning of the study. The majority of the students were Hispanic (71.4%), while others were Caucasian (24.5%), Black (2.0%), and Native American (2.0%). With regard to gender, 73.5 percent of the students were female and 26.5 percent were male. Students initially in the experimental group ($N = 45$) averaged 25.71 years of age, had earned a grade point average of 2.79, had already completed 34.89 hours at the beginning of the semester, and were enrolled in 11.80 semester hours at the beginning of the study. The majority of the students were Hispanic (60.0%), while others were Caucasian (40%). With regard to gender, 73.3 percent were female and 26.7 percent were male.

Experimental Design

The study included the use of control and experimental groups in a quasi-experimental pretest-posttest control group design to determine the effects of the experimental treatment on the students. The design allowed for an investigation of the variables as well as interaction effects and assumed dependent variable scores that were interval or ratio, a normal distribution of scores, the same variance in the population, and independent samples.

The independent variables in the study were participation and nonparticipation of control and experimental groups in a student generated questioning technique. The dependent variables included (a) the effect of treatment on students' mean scores on a comprehensive end-of-course examination; (b) the effect of treatment on students' mean scores on the portion of the Learning and Study Strategies Inventory (LASSI) that reflects information processing; and (c) the effect of treatment on students' mean scores on the California Critical Thinking Skills Test (CCTST).

Instrumentation

Instruments included in this research study were (1) the Learning and Study Strategies Inventory (LASSI), (2) the California Critical Thinking Skills Test (CCTST), and (3) an end-of-course comprehensive examination in Human Anatomy and Physiology.

The end-of-course comprehensive examination for Human Anatomy and Physiology I was a teacher-generated instrument that included 150 multiple-choice questions. The questions were designed to measure factual recall as well as the application of critical thinking skills. The appropriateness of the questions asked, with regard to their ability to elicit critical thinking skills, was determined with the assistance of peer consultation. The instructor of the course within which the current study was conducted designed the end-of-course examination. And, the examination itself was tested for its internal consistency using Cronbach's Alpha, a statistical measure of which the Kuder-Richardson coefficient is a special case (Cronbach, 1951). Cronbach's Alpha yielded an estimate of the correlation between items on the test, and the value expressed by the statistical test was considered a validation of the homogeneity of these items. For the end-of-course examination, Cronbach's Alpha was determined to be a value of 0.89.

The Learning and Study Strategies Inventory (Weinstein, 1987) is a 77-item diagnostic/prescriptive self-report measure of strategic learning that focuses on thoughts and behaviors that can be changed and enhanced through educational interventions. The items on the information processing scale address how well

students can use imaginative and verbal elaboration, organization strategies, and reasoning skills to help build bridges between what they already know and what they are trying to learn and remember (Weinstein, 1994b). The psychological basis for the instrument stems from a general information-processing concept which postulates that students who try to integrate new material with prior knowledge are more likely to understand and learn the new material (Pintrich & Johnson, 1990).

The LASSI includes ten individual scales that measure attitude, motivation, time management, anxiety, concentration, information processing, selecting main ideas, study aids, self testing, and test strategies. The Alpha Coefficient for the Information Processing scale of LASSI is .83, and the test-retest correlation coefficient is .72. The Information Processing portion of the instrument measures how well students can use elaboration and organization to assist their recall and understanding. The appropriateness of the measure stems from the fact that their ability to learn efficiently and effectively, both on their own and in the classroom, is aided with the use of information processing (Weinstein, 1987).

The California Critical Thinking Skills Test, Form B, measures critical thinking skills through the use of short problem statements and descriptive scenarios (Facione, 1992). The test format contains 34 multiple-choice questions whose content is discipline-neutral. The overall KR-20 (Kuder-Richardson) reliability is .71 for Form B. Individual scores are also intended to indicate facility in inductive and deductive reasoning as well as analysis, inference, and evaluation.

The norm group used for establishing the California Critical Thinking Skills Test exhibited a mean score of 15.89 with a standard deviation of 4.457 (Facione & Facione, 1994). The group included students at an urban, state university who had completed college preparatory courses, averaged 22 years of age, and 19% of whom indicated a native language other than English (Facione & Facione, 1994). In comparison, it is highly probable that community college student performance may differ considerably from the established norm, due to the inherent heterogeneity of a community college population. However, it was felt that use of this testing instrument would still allow for a relative comparison of any differences between the control and experimental groups.

An informal survey was also conducted to further delineate the profile of students who participated in this study. In an effort to characterize some of the obligations that they faced outside the school environment, all students were asked to indicate the number of hours they worked each week, their marital status, and the number of persons living in their household. Additionally, they identified whether they were the first individual in their household to attend college, and the educational level of their parents. Other data obtained from college admission records included age, gender, grade point average, college hours completed, and college hours in which the students were enrolled during the semester of the study.

Treatment

For all classes participating in the study, the course content was the same and was presented in a lecture format. Students in Human Anatomy and Physiology I receive instruction in curricular material relating to anatomical terminology, the cell, basic chemistry, and the integumentary, skeletal, muscular, and nervous systems of the human body. The four classes included in the study were assigned to one instructor in order to minimize the possible influence of variation in pedagogical styles. The instructor had 15 years of teaching experience, six of which were in Human Anatomy and Physiology.

During the third class meeting of the semester, students in each of the classes included in the study were assessed by means of a pretest to ascertain their personal inventory of learning and study strategies. The instrument used for the assessment was LASSI (Weinstein, 1987). During the fourth class meeting, students were pretested for critical thinking skills using CCTST (Facione, 1992).

Members of the treatment group were taught to apply a technique that required them to generate questions (King, 1990, 1992). The technique used a set of generic question stems that students filled in with content

covered in the lecture class. The question stems had been identified as to the level of cognition each demonstrated. The technique was introduced only to the treatment groups beginning the fourth class meeting where participants were told of the success effected by use of techniques to help students learn more complex methods of thinking. Following distribution of a reference sheet containing the question stems (Arburn, 1998), questions were generated with the help of the instructor as students were taught how to construct questions using the stems. The question stems were intended to work as scaffolds in that they supported students as they learned to ask questions and also reduced the complexity of the technique as it was being learned. However, the question stems did not specify each step a student needed to perform in order to actually generate a question. The choice of the stem and its completion, much like composing a fill-in-the-blank question, were left to the student (Schrag, 1992).

Three sessions of 15 minutes each were expected to provide adequate time for the students to learn how to use the question stems (King, 1989). During the last 15 minutes of the fourth and fifth class session, therefore, members of the experimental groups were given time for additional practice in the use of the question stems. The questioning technique was then used for a period of eight weeks with the treatment group. The time period of treatment was based on early studies using guided questions in which six successive lectures within a three month semester produced significant results with regard to improvement in university students' achievement (King, 1989).

Upon entering the classroom, students were assigned a number that placed them into groups of two. After a lecture presentation, the students were given five minutes to individually compose and write down a question based on the lecture content, but utilizing the stems. Students then took an additional five minutes to pose the question to their partner and both students took turns answering each other's question. The questions were collected by the instructor, collated, and compiled in a handout that was returned to the students.

During the fourth class session, members of the control group were also told that classroom techniques had been developed that had helped students learn more complex methods of thinking. The participants in this group received supplementary course material throughout the study that was in the form of textual materials and included only vocabulary lists. While these materials were useful to students, they did not address any specific techniques used to improve critical thinking skills. The purpose of this distribution was to give members of the control group the impression that they were participating in a regimen similar to the treatment group, although this was not the case.

At the conclusion of the semester, an end-of-course examination, the Learning and Study Strategies Inventory, and the California Critical Thinking Skills Test were administered to both the control and experimental groups. Although the three assessment instruments were administered during regularly scheduled class periods, only one assessment instrument was administered during any one class period. On the same day, all groups of students participated in the respective assessments during their own class periods. The LASSI was administered during the class period immediately following the last treatment. The CCTST was completed in each class on the last day of regular instruction. The final examination was completed on the official final examination date scheduled by the college for the respective classes.

Data Analyses

When comparing groups, such as control and experimental, one can expect variability among the performance of members of the groups. Not only may individuals within a group vary among themselves with regard to performance, but also members of one group may initially vary from the other group with regard to a dimension relevant to the dependent measure. The variation that occurs may be due not only to differences among the members, but to measurement error as well (Borich, 1996). An analysis of variance (ANOVA) is a statistical test that attempts to maximize any differences between groups that may be due to the experimental treatment and minimize any variance due to a chance fluctuation of scores. This statistical test also controls for variance that may have influenced the overall results but is not of primary interest in the investigation. Within ANOVA is a test statistic, F , which expresses the mathematical relationship of variance within groups compared to variance between groups and becomes an index for determining the significance

between the means of the respective groups. The F value is then used to determine "p," an expression of significance.

In this study, the value used for "p" was 0.05, indicating that the probability of the results being attributable to chance were 0.05 or 5 out of 100. Therefore, if statistical tests showed a p value equal to or smaller than 0.05, the results would be considered attributable to the intervention and, therefore, significant. On the other hand, if the p value obtained were greater than 0.05, results would not be significant.

The classes used in this study were randomly assigned to either a control or experimental group. However, they were intact classes that were selected by the students and not classes into which the students were randomly placed after careful identification. It is possible, therefore, that differences may have existed among the groups or classes themselves that would have a bearing on the outcome of the study. In order to adjust statistically for any initial differences that may have existed among these groups the individual group means were examined using the statistical test known as analysis of covariance (ANCOVA). In this test, one or more concomitant variables that may be related to the dependent variable, or could influence it, are designated as covariates and are measured together with the dependent variable. Covariates used in the present study included performance on pretests and, in the case of the end-of-course examination, the Grade Point Average (GPA) earned by the students prior to enrolling in the classes being observed.

Statistical analyses of data were performed using SPSS⁷ 7.5 for Windows 95. Tests included Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA). Data used included final course examination scores, LASSI scores, and CCTST scores for both the control and experimental groups. In examining final course examination scores by ANCOVA, Grade Point Average (GPA) was used as a covariate in the analysis.

Results

Student Profile

A total of N = 94 students in Human Anatomy and Physiology were included when this study was initiated. However, due to an attrition rate that was not unexpected in this subject area, only N = 68 students completed the study. Although all students were given pretests at the beginning of the semester, only 68 students remaining in the classes completed the posttests and all other requirements of the study. Statistical data, therefore, was based on analysis of the performance of the students who participated completely in the entire study (N = 68).

Members of the control group included N = 37 students. The students averaged 23.70 years of age, had earned a grade point average of 3.01, began the semester having completed 21.95 hours, and were enrolled in 11.95 semester hours at the beginning of the semester during which the study was conducted. The majority of these students were Hispanic (67.6%), while others were Caucasian (27.0%), Black (2.7%), and Native American (2.7%). With regard to gender, 73.0 percent were female and 27.0 percent were male. A survey conducted early in the semester indicated that 58.4 percent of the students came from families whose parents had no formal education beyond high school, while 41.6 percent indicated that either one or both parents had obtained an undergraduate, graduate, or postgraduate degree. Asked whether they were the first person in their household to attend college, 76.5 percent responded "no" and 23.5 percent responded "yes". The identification of the other college attendees in the household was not specified, so students may have included their parents, peers, spouses, or children.

A total of N = 31 students participated in the experimental group. The students averaged 27.29 years of age, had earned a grade point average of 2.83, and began the semester having completed 43.39 hours, including two students who had each completed more than 125 semester hours. All students were enrolled in 11.71 semester hours at the beginning of the study. The majority of the students were Hispanic (54.8%), while the remaining were Caucasian (45.2%). With regard to gender, most of the students were female (74.2%), with fewer males in the class (25.8%). Many of the students (64.5%) came from families whose parents had no

formal education beyond high school, while the remainder indicated that either one or both parents had obtained an undergraduate, graduate, or postgraduate degree (35.5%). Asked whether they were the first person in their household to attend college, most responded "no" (58.1%) and fewer responded "yes" (41.9%).

Subjects in the control group indicated they worked an average of 20.58 hours per week and lived in households which averaged 3.83 persons in number, including them. The majority were single individuals (66.6%), while the rest of the group included either married students (30.6%) or single parents (2.8%). In the experimental group, the average number of hours worked each week was 22.38. The households of these subjects averaged 4.25 persons. The majority were single individuals (51.6%), while the remainder included married individuals (25.8%) and single parents (22.6%).

Student Generated Questions

The questions generated by the students in the experimental group were categorized according to the question stem used and the thinking skill assigned to each stem. The most frequent selection of a question stem by the students appears to have favored those questions that were directed toward comparison and contrast. A pattern of selection for the use of other question stems was not apparent.

Performance on End-of-Course Examination

Final course examination scores were statistically analyzed to determine whether the treatment had affected the academic performance of the students as measured by the examination. Students' Grade Point Average was used in lieu of a pretest score. The means and standard deviations for the respective groups are shown here.

Table 1: Grade Point Average and End-of-Course Examination Means and Standard Deviations (N=68)

Source of Variation	N	Pretest Scores*		Posttest Scores	
		Mean	Standard Deviation	Mean	Standard Deviation
Control	37	3.01	0.71	78.38	10.68
Experimental	31	2.83	0.60	76.32	11.60

*Grade Point Average

Although classes were randomly assigned to either the control or experimental group, intact classes were used. Therefore, to adjust for initial differences that may have existed among the groups, the individual group means were examined using an analysis of covariance (ANCOVA). The covariate was individual students' Grade Point Average upon entry into the course. Statistical analysis of covariance yielded an $F = 0.003$ and $p = 0.959$, indicating there was no significance between the groups with regard to their performance on the examination. Analysis (ANCOVA) of student performance on the subset of 42 questions which required application of critical thinking also indicated no significance, with $F = 0.930$ and $p = 0.339$. These results indicated there was no difference in the mean scores on an end of semester examination given to students who used a student-generated questioning technique in Human Anatomy and Physiology lecture classes compared with students who did not use the technique.

Table 2: End-of-Course-Examination ANCOVA Results (N = 68)

Source of Variation	SS	df	MS	F	p
Covariate:					
Presemester GPA	2025.947	1	2025.947	21.792	.000
Main Effects:					
Experimental versus Control Group	.244	1	.244	.003	.959
Model	2074.380	2	1037.190	11.157	.000
Residual	5949.799	64	92.966		
Total	8024.179	66	121.578		

Performance on Learning and Study Strategies (LASSI)

Pretest and Posttest scores on the Learning and Study Strategies Inventory (LASSI) were then statistically analyzed. The analysis was applied to determine whether the treatment had affected the incidence of information processing skills in the students' inventory of information processing strategies. Analysis was therefore directed at the Information Processing scale as an index of measure of critical thinking strategy acquisition. Means and standard deviations for the respective groups are shown here.

Table 3: Learning and Study Strategies Inventory (Information Processing Scale Score) Means and Standard Deviations (N=68)

Source of Variation	N	Pretest Scores		Posttest Scores	
		Mean	Standard Deviation	Mean	Standard Deviation
Control	37	29.86	5.54	31.54	4.87
Experimental	31	27.35	5.41	29.61	5.80

Application of ANCOVA revealed no significant difference between the control and experimental groups with regard to their performance on the information-processing portion of the LASSI. The posttest scale scores were compared with the use of pretest scale scores as a covariate. The statistical test yielded an $F = 0.267$, $p = 0.607$ for the main effects and was conducted at a significance level of $\alpha = 0.05$. These findings indicated that there was no difference in the mean scores on the Information Processing Skills scale of the Learning and Study Strategies Inventory (LASSI) of community college students who used a student-generated questioning technique in Human Anatomy and Physiology lecture classes compared with students who did not use the technique.

Table 4: Learning and Study Strategies Inventory Posttest (Information Processing Scale Score) ANCOVA Results (N = 68)

Source of Variation	SS	df	MS	F	p
Covariate:	576.114	1	576.114	29.110	.000
LASSI Pretest	5.291	1	5.291	.267	.607
Main Effects:					
Experimental versus Control Group					
Model	638.791	2	319.395	16.138	.000
Residual	1286.430	65	19.791		
Total	1925.221	67	28.735		

Performance on California Critical Thinking Skills Test (CCTST)

Statistical analysis of pretest and posttest scores on the California Critical Thinking Skills Test (CCTST) was applied to determine whether the treatment had affected the students' facility in inductive and deductive reasoning as well as analysis, inference, and evaluation. Means and standard deviations for the respective groups are shown here.

Table 5: California Critical Thinking Skills Test Means and Standard Deviations (N=68)

Source of Variation	N	Pretest Scores		Posttest Scores	
		Mean	Standard Deviation	Mean	Standard Deviation
Control	37	12.19	4.07	13.46	3.93
Experimental	31	10.94	3.84	11.23	4.12

Application of ANCOVA revealed no significant difference between the control and experimental groups with regard to their performance on the posttest California Critical Thinking Test. The statistical test yielded an $F = 3.479$, $p = .067$ and was conducted at a significance level of $\alpha = 0.05$. It was concluded that there was no significant difference in the mean scores on the California Critical Thinking Skills Test of community college students who used a student-generated questioning technique in Human Anatomy and Physiology lecture classes compared with students who did not use the technique.

Table 6: California Critical Thinking Skills Test Posttest ANCOVA Results (N = 68)

Source of Variation	SS	df	MS	F	P
Covariate:	479.794	1	479.794		.000
CCTST Posttest				53.146	
	31.411	1	31.411		.067
Main Effects:				3.479	
Experimental versus Control Group					
Model	563.950	2	281.975	31.234	.000
Residual	586.814	65	9.028		
Total	1150.765	67	17.176		

Earlier in this discussion, it was noted that student responses to the California Critical Thinking Skills Test could also be categorized within two non-overlapping sets of indices. One perspective showed the number of correct responses to questions designed to measure the use of inference, analysis, and evaluation. The other perspective indicated correct responses to questions demonstrating the use of inductive or deductive reasoning (Facione, 1992). Further statistical analysis pertaining to these specific indices revealed an increase in the use of inference and deductive reasoning by the students in the experimental group.

Table 7: California Critical Thinking Skills Test Indices Posttest ANCOVA Results**(N = 68)***

Index Measured	Source of Variation	SS	df	MS	F	p
Inference	Covariate	38.526	1	38.526	12.167	.001
	Main Effects	16.182	1	16.182	5.111	.027
	Model	80.066	2	80.066	12.643	.000
Analysis	Covariate	37.931	1	37.931	16.121	.000
	Main Effects	.948	1	.948	.403	.528
	Model	38.065	2	19.032	8.089	.001
Evaluation	Covariate	83.450	1	83.450	22.144	.000
	Main Effects	6.921	1	6.921	1.836	.180
	Model	97.559	2	48.779	12.944	.000
Induction	Covariate	90.439	1	90.439	20.469	.000
	Main Effects	7.330	1	7.330	1.659	.202
	Model	101.338	2	50.669	11.468	.000
Deduction	Covariate	146.312	1	146.312	.000	.000
	Main Effects	24.871	1	24.871	6.990	.010
	Model	219.242	2	109.621	30.809	.000

*(Covariates used were the respective Pretests for each measure).

Conclusions and Discussion

Will the use of a guided student-generated questioning technique in Human Anatomy and Physiology lecture classes increase the academic performance and the incidence of critical thinking skills of community college students? Based on the current study, one would have to conclude that the technique did not effect the expected increases since the nature of the data obtained resulted in a failure to reject the proposed null research hypotheses stated earlier.

It should be noted that failure to find significance did not negate the findings of earlier studies that showed that the use of student-generated questioning techniques resulted in improved lecture comprehension on the part of university students (King, 1989). In the studies by King, the technique actually proved more effective than independent review and peer questioning in small cooperative groups. A review of 26 studies in which students were taught to generate questions concluded that of all methods employed, signal words and generic questions or question stems resulted in the greatest improvement in comprehension (Rosenshine, Meister, & Chapman, 1996).

Why did the current study fail to show similar results? An explanation for this disparity could be sought in a critical examination of the parameters of the study, although characteristics of length of intervention, mode of application, and evaluative methods that were used fit the general profile of previous studies. What differed, however, were the population of students and the nature of the content material. Perhaps an interface between students who may not be academically prepared and content material that is technically complex and challenging may be a chasm that requires a longer period of intervention in order to be effectively traversed. It may be necessary to manipulate the length or type of intervention in order to provide a viable option and provide further clarification of the issue.

On a positive note, it would be constructive to illustrate a benefit that was elucidated as a result of the current study. What may be concluded is that the use of the questioning technique did not serve to diminish the performance of students on the final examination. This should provide encouragement to many teachers in disciplines which are so content intensive that they give instructors cause to resist relinquishing the podium to methods of instruction that are less didactic in nature. Frequently, there is a concern that material will not be thoroughly or appropriately addressed during the course of the class if it is not addressed by way of a lecture. To cling to this attitude may not only prove fallacious but may deprive students of an opportunity to gain higher cognitive skills that are needed in order to appropriately assimilate and apply the content that has been addressed.

With regard to other aspects of the current study, the use of a questioning technique did not result in an increase in student's personal inventory of an information processing strategy. This is unfortunate, since the ability to process information enhances critical thinking and the use of information processing strategies is an indicator of how well students use elaboration and organization to assist in recall and understanding (Weinstein, 1987). The use of elaboration, in the form of elaborative interrogation, contributes to the learning process because it encourages comparison of new knowledge to what is already known (Woloshyn, Paivio, & Pressley 1994). By encouraging the learner to question the meaning of new material, the learner will actively construct meaning (Yager & Lutz, 1994). Both individual learning, and learning through social interaction are particularly beneficial in learning science concepts (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Since generating questions is a form of elaboration and participating in exchange with a peer enhances the comparative process, it is interesting to note that this intervention did not result in a measurable attainment of the information processing strategy.

In an effort to understand the results, it may again be relevant to consider the nature of the material being learned and the disposition of the learner. At-risk students with academic and social backgrounds that may

be limited are confronting a content arena replete with new vocabulary and extensive, interrelated concepts. Their mastery of appropriate reading and writing skills is frequently deficient, and some are further challenged by the need to both think and express themselves in a second language. Under these circumstances, relating new material to that which is already known may not present itself as a feasible, urgent, or prime strategy choice. The immediate demand for simply organizing and consuming a massive amount of new material may have a tendency to overshadow or displace the need for more appropriate assimilation of the material. If this is the case, the instructor must more actively assume the responsibility of assisting students in this task by providing opportunities to help them relate the subject matter to their own, though possibly limited, realm of experience. A study by Collins and Smith (as cited in Wong, 1985) has shown that a lack of prior knowledge may make it difficult to understand information that has been presented. However, unsuccessful activation of prior knowledge may be an even more important problem to examine and attempt to change (Bransford, Stein, Vye, Franks, Auble, Mezynski, & Perfetto, 1982).

The necessity for seeking ways to master new material effectively may explain why significant results were found with regard to the LASSI scale that measured use of a strategy to select main ideas. As students progress through a course that is very content intensive, this would be an important strategy to learn. And, having to generate questions based on the material appears to have contributed to the development of this strategy in the experimental group of students. Improving one's ability to focus on material that is more important maximizes the efficiency of studying efforts (Weinstein, 1987). Perhaps use of the questioning enhanced development of the strategy due to the fact that students had to identify important points within the lecture material on which to base their questions.

The California Critical Thinking Skills Test included non-overlapping indices that measured a) use of inference, analysis, and evaluation, and b) use of inductive and deductive reasoning. Significant results were found that indicated an increase had occurred in the use of inference and deductive reasoning by students who participated in the application of the questioning technique. Inference, as used on the California Critical Thinking Skills Test, indicates a facility for identifying information needed to draw a conclusion or formulate a hypothesis (Facione, 1992). Enhancing the ability to reason and draw a conclusion from evidence or factual information that is presented would be beneficial to a clinician, diagnostician, scientist, or even the average consumer. For example if presented with a variety of symptoms such as fever, vomiting, and a sharp pain in the LRQ (Lower Right Quadrant) of the abdominal region, appendicitis could be suggested as the possible cause for discomfort in a patient. Having the ability to offer a plausible explanation for a problem, based on evidence given, could elevate an individual from the passive role of receiver of information to the active position of being a more discriminatory and powerful agent of control.

The increase in the incidence of use of deductive reasoning by students in this study is also a cause for celebration. Typically, deduction connotes the ability to reach a conclusion by reasoning from a general premise to a more specific conclusion. While syllogisms or mathematical proofs provide examples of deduction (Facione & Facione, 1994), its usefulness is not limited to these applications. In fact, one could look at another clinical example to illustrate deduction. If your patient had diabetes, what complications might be anticipated? It is not unreasonable to expect circulatory complications that could become manifest as problems with vision, the kidneys, or ulceration on the feet and legs that could even become gangrenous if left untreated.

In summary, the absence of improvement in achievement failed to confirm results of earlier studies where intervention based on generating questions was successful (King, 1989; Redfield & Rousseau, 1981; Rosenshine, Meister, & Chapman, 1996; Wong, 1985). Positive results were obtained, however, in the ability of students to select main ideas and engage in inference and deductive reasoning.

Recommendations for Future Study

Completion of this study has shown that at-risk community college students in Human Anatomy and Physiology can be assisted in their acquisition of strategies for learning to think critically. While it did not significantly affect achievement, the use of a technique requiring them to generate questions based on the content of lecture material did result in improving their ability to select main ideas, use inference, and apply deductive reasoning. Additionally, several questions for future research have been suggested by the findings.

Would implementation of the technique for the duration of more than one semester result in improving achievement or other aspects of critical thinking skills? If the skills are developmental in nature, more time may be the answer. A review of intervention studies that involved question generation has indicated that significant results were obtained in studies which ranged from a training period of 4 to 25 sessions (Rosenshine, et al., 1996). Given the background of students in the current study, a period of implementation longer than one semester may more effectively derive greater benefits.

Are the effects of the treatment long term and far reaching? Garner (1990) has suggested that students will not have a propensity toward using strategies outside the context in which they are trained. Perhaps additional insight could be gained by monitoring the progress of students on a long-term basis and re-evaluating them following a further semester of non-intervention. A review of 26 studies that taught question generation showed a maximum follow-up assessment period of three months was utilized (Rosenshine, et al., 1996). While such a study would be interesting, it is probable that appropriate control of variables would become logistically challenging in a college environment due to the variety in numbers and kinds of courses that students pursue. If results were found, it might be difficult to attribute them to a specific cause unless one had a particularly large population with which to work.

Would valuable insight be gained if qualitative research techniques were also pursued in investigating the effects of using student-generated questioning techniques? Even though they fell outside the reach of the testing instruments that were utilized, some reflections from the perspective of the teacher warrant inclusion in the discussion of the current study. Seen individually, five or six members of the experimental group who appeared to be experiencing the most difficulty with the class may have derived the greatest benefit from this study. Class demeanor became more relaxed and performance on examinations slowly improved. Their personal performance on the general posttest scores of the California Critical Thinking Skills Test demonstrated great improvement and, in almost every case, was more than double the value of their pretest score. Although changes in these individuals were not of enough consequence to alter the significance of the entire measurable class performance, a transformation of note seems to have occurred within their personal academic experience during the semester. It may be extremely valuable to further investigate responses of individual students as they progress through a semester of implementation of the questioning technique.

Has acquisition of facility in critical thinking skills contributed to empowering the learner? The suggestion has been made that it is not always sufficient to learn skills without learning when to access or use the skills (Derry & Murphy, 1986). However, only a few question generation studies have demonstrated that students have acquired mastery over the techniques (Smith, 1977; Wong, Wong, Perry, & Sawatsky, 1986). It would be interesting to combine the use of the questioning technique with a measurement of locus of control exhibited by the student. Further qualitative assessment may also serve to shed light on any subtle changes that could be occurring in the learners during the period of intervention that are suggestive of their establishing ownership over the learning process.

While community college teachers have long been recognized for their interest in students and the improvement of pedagogy, their ability to effectively reach and teach non-traditional and at-risk students continues to remain a challenge. The study undertaken here and the areas of success that it served to demonstrate are offered as a valuable addition to a repertoire of easily applied, reliable, and productive techniques. All that is required is a commitment to relinquish time from the podium in order to introduce students to the purpose and method of the technique to be used, allow time for its practice, and celebrate in the expectation that students will most certainly derive benefit from its use.

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