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An Assessment of the Active Learning Worksheets in an Undergraduate Human Anatomy and Physiology Course

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Abstract

Anatomy & Physiology I is a demanding gateway science course for community college students. It is particularly challenging for underrepresented Hispanic students who must navigate course content, language barriers, and work-related time constraints. This paper introduces a new active learning strategy to promote meaningful learning and conceptual understanding of Anatomy & Physiology, enhancing students' academic success. The teaching strategy incorporates enhanced lecture presentations and discussions. It also includes periodic pauses for students to engage in active learning activities aligned with learning outcomes. These activities spark student interest and provide immediate feedback on their understanding of challenging topics. The study indicates that the pass rate, mainly grades of C+ and above (a requirement in all nursing courses), was consistently higher for active learning participants than those who attended traditional lectures. This evidence suggests that an active learning environment boosts academic performance among our ethnically diverse students.

Keywords: Active learning, Anatomy & Physiology, Undergraduate Hispanic-serving institution.

Resumen

Anatomía y Fisiología 1 es un curso de ciencias introductorio y obligatorio muy exigente para estudiantes en Colegios Comunitarios. Este curso es especialmente difícil para estudiantes hispanos que deben cubrir todo el contenido del curso, sortear las barreras del idioma, y lidiar con limitaciones de tiempo asociadas con trabajar. Este artículo presenta una estrategia de aprendizaje activo para estimular el aprendizaje y la comprensión de conceptos en Anatomía y Fisiología, y a la vez mejorar el éxito académico de los estudiantes. La estrategia de enseñanza consiste en clases teóricas enriquecidas y debates. También incluye descansos periódicos durante las clases teóricas para que los estudiantes participen activamente de actividades alineadas con los objetivos de aprendizaje del curso. Estas actividades despiertan el interés de los alumnos y brindan información para el profesor sobre su comprensión de temas difíciles. El resultado de utilizar esta estrategia de enseñanza muestra que la tasa de aprobación, principalmente calificaciones de C+ y más (lo cual es requisito de todos los cursos de enfermería), fue consistentemente mayor entre estudiantes que participaron de teóricas con aprendizaje activo que entre estudiantes de teóricas tradicionales. Estos resultados sugieren que el aprendizaje activo aumenta el rendimiento académico de los estudiantes.

Palabras claves: Aprendizaje activo, Anatomía y Fisiología, Institución de pregrado al servicio de hispanos.

Introduction

Human Anatomy and Physiology I is often a challenging course known for high dropout, withdrawal, and failure rates (Harris et al., 2004; Sturges et al., 2016). While various reasons contribute to this, some researchers suggest that the inherent features of the discipline itself complicate learning, irrespective of instructional factors or student characteristics (Slominski et al., 2019). Others attribute this difficulty to ineffective study strategies (Husmann, 2015) and a need for foundational biological knowledge (McKee, 2002). Bronx Community College (BCC), a Hispanic-serving institution, has a student body of approximately 60% Hispanic and 30% African ethnic backgrounds. Despite the popularity of the Anatomy & Physiology course, it has a high failure rate, with less than 30% of students achieving the required standard (Atamturktur et al., 2015). Time constraints due to family and work responsibilities further challenge the students and their learning.

Studies show that student-centered, active learning strategies promote meaningful learning, content retention, improved attitudes, and critical thinking skills (Yager, 1991; Klionsky, 1998; Lawson, 2001; Lord, 2001; Michael, 2006; Daniel, 2016). Small-group cooperative learning activities are practical in college science classrooms. They provide a social context for students to understand the content and actively engage in the science material (Astin, 1993; Tobin & McRobbie, 1999). These activities may be particularly effective for English language learners who may feel isolated and disengaged from a science course.

Many Anatomy & Physiology students fail or drop out because of passive learning. This approach, common in High School, relies on focused listening and is often sufficient for test preparation. While this method is enjoyable and requires less effort, there are more efficient ways to learn. In college, it proves to be ineffective. Successful studying relies on meaningful learning, which involves active participation. Active learning typically involves collaboration and encourages students to reflect on their actions (Lord, 1997). Active learning is a process where students participate in activities and "think about the things they are doing" (Bonwell & Eison, 1991, p.19). It is also defined as "anything course-related that all students in a class session are called upon to do, other than merely watching, listening, and taking notes" (Felder & Brent, 2009; p.2).

In this study, using the student-centered framework, lecture activity worksheets were introduced during each lecture session to enhance students' success rates. These worksheets included labeling exercises, short answers, multiple-choice, true-or-false questions, and concept mapping. This method, which prioritized active participation over passive listening, improved the course's pass rates and student grades.

Methods

A study was conducted on two large cohorts of undergraduate Anatomy & Physiology I students, with both cohorts being taught by the same instructor over multiple semesters but using different teaching methodologies. This prerequisite course is required for all Allied Health program participants. The control group was taught using a traditional,

teacher-centered method. This method involved lectures, models, and occasional quizzes to assess understanding. The class met for 2h:30 minutes once a week, and the instructional material was presented using PowerPoint slides, figurative models, and demonstrations. The traditional method also included showing a few short video clips on a few occasions during the semester to reinforce the material presented in lectures. Although students were encouraged to ask questions during the class, student-to-student interaction was rarely observed. The group also attended a weekly hands-on laboratory.

On the other hand, the experimental group was taught using active learning worksheets, a student-centered approach. This group also met for 2h:30 minutes once a week and attended a weekly hands-on laboratory. However, each session began with a specific activity to excite students' interest in the day's topic (see Exhibit A). These activities varied from a short video clip about the material to concept maps, diagrams, a case study, matching, and critical thinking questions. The instructor arranged all these introductory activities to engage and motivate the students for the coming lecture presentation. The students in this group were unaware that this teaching method differed from previous years, as they had no opportunity to compare it with their counterparts in the control group. Overall, this teaching method was classified as "student-centered."

Data Collection and Analyses

This study assessed two primary data sources: unit exams and the final exam grades. Both groups were subjected to the same unit exams and the final exam. The final exam consisted of 75 multiple-choice questions. The exam was cumulative, with 25 common questions (the same for all Anatomy and Physiology sections) and 50 unique questions the

instructor chose. Additionally, the rates of C+ and above for both groups were also calculated, as these are the minimum passing grades required for allied health programs: Nursing, Nuclear Medicine, and Radiological Technology. The data were analyzed using student t-tests and descriptive statistics to test the hypothesis and determine each approach's effectiveness in achieving course goals. A p-value < 0.05 was considered significant.

Results

The academic performances of 172 students enrolled in Anatomy & Physiology I over twelve consecutive semesters were analyzed. This analysis excluded students who received non-academic grades such as "Withdrawals" and "Incompletes." Of these students, 82 completed the course using active learning worksheets, representing approximately 48% of the total. Course-based outcomes, including pass rate, the rate of students earning grades C+ or above, and average course grade, are listed in Table 1 for each academic year. These outcomes were compared between students who participated in active learning lectures and those who attended traditional lectures, with the latter forming the majority.

For each semester, active learning sections consistently had higher pass rates than traditional ones. The level of consistency was evaluated over time, with means and standard errors of means for the measured parameters calculated (Fig. 1). Across all twelve semesters, the average rate of students passing the course was 94.2% for active learning participants and 65.1% for traditional ones, indicating a 29% improvement for those in the active learning classes. The relatively low standard error of the mean (1.9 for active learning participants and 5.8 for traditional classes) shows a significant degree of

consistency in passing rates over time. A t-test analysis was conducted to determine if the 29% improvement in the passing rate was statistically significant. The two-tailed p-value (0.0008) was proven statistically significant.

In this course, grades of C+ and above are considered high achieving. During all twelve semesters, there was a significant increase in these high-achieving grades among active learning participants (42%) compared to those in traditional classes (17%; Fig. 2). A t-test analysis confirmed this difference as statistically significant ($p = 0.029$; $t=3.912$ $df=10$). The data also shows that the differences between the two groups decreased in the last four semesters, possibly due to smaller enrollments.

Discussion

This study examined the effect of active learning worksheets on students' performance in an Anatomy and Physiology I class at a Hispanic-serving community college. I have incorporated active learning worksheets into the lecture timeline to make learning more enjoyable and motivating. This interactive format allowed the instructor to assess how effectively students understood, retained, and applied the lecture content in real-time. It also gave students a unique opportunity to self-assess their knowledge in specific areas of a topic while making connections between concepts introduced by the instructor or applying their knowledge to solve problems. This student-centered method allows students to discuss or engage in inquiry-based exercises. Similar teaching methods have proven effective in lectures and laboratories for General Biology and Environmental Science at Indiana University of Pennsylvania (Lord, 1997, 1998, 1999).

The reported results showed that these worksheets increased the course pass rate by an average of 29% over twelve semesters compared to students who attended traditional, often instructor-centered, lectures. The consistent improvement over time (Fig.1) suggests that active learning worksheets might substantially impact student learning. This could be particularly beneficial for English language learners, who often need help with the pace of traditionally taught lectures. Traditional science teaching usually relies on delivering facts through lectures (Bonwell, 2006) and frequently requires students to memorize extensive lists of specialized vocabulary (Leonard et al., 2001). Generally, this approach results in a lack of student motivation for the sciences. Additionally, it often leads to limited learning, as evidenced by poor content retention, a lack of scientific skills, and an inability to apply concepts.

In agreement with previous reports on student-centered instructions (Rao & Di Carlo, 2001; Burrowes, 2003; Prince, 2004; Thaman et al., 2013; Murphy et al., 2021), this study shows that teaching in a constructivist, active learning environment is more effective than traditional methods in promoting academic achievement, enhancing conceptual understanding, developing higher-level thinking skills, and increasing students' interest in biological sciences. In their final course evaluations, students from the active learning sections reported that they enjoyed this class more than traditional ones. They felt they learned more; they could discuss and solve problems collectively in their collaborative groups, and, importantly, they always maintained focus (data not reported).

The findings presented here suggest that using activity worksheets results in higher passing rates and increased grades of C+ and above. Instead of passive listening, interactive

lecture activities make learning more engaging, stimulating, and enjoyable for students. As a result, my active learning course participants performed significantly better due to an enhanced understanding of critical topics and improved exam preparation. Additionally, the worksheets have been extremely useful in evaluating student understanding and knowledge, making them well-suited for classroom formative assessment. This demonstrates the numerous advantages of implementing active learning worksheets.

Thus, while the constructivist method requires more time and effort from the professor for preparation, organization, and grading, active learning is more effective for our current generation of students. Thus far, I have chosen to concentrate primarily on problem-based learning activities. These activities are typically more concise and less open-ended than case studies, making them easier to incorporate into the existing lecture structure. In upcoming semesters, I will focus on devising more active learning exercises to boost student engagement and comprehension of the material and prepare students to address real-world complex problems.

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Figures and Tables

Exhibit A

A snapshot of Active Learning Worksheets for the A&P lecture class

Chapter 1: Major Themes of Anatomy and Physiology

I. Learning Objectives

When you have completed this section, you should be able to:

Obj.1 Human Structure (pp. 12–15),

- *list the levels of human structure from the most complex to the simplest*

Obj.2 Human Function (pp. 15–19),

- *state the characteristics that distinguish living organisms from nonliving objects*
- *define homeostasis and explain why this concept is central to physiology*
- *define negative feedback and explain its importance to homeostasis*
- *define positive feedback and explain its beneficial and harmful effects*

II. Multiple Choice Questions

Obj.1 **1.** The smallest living units in the body are:

a. elements
b. sub-atomic particles
c. cells
d. molecules

Obj.1 **2.** The level of organization that reflects the interactions between organ systems is the:

a. cellular level
b. tissue level
c. molecular level
d. organism

Obj. 1 **9.** In complex organisms such as the human being, cells unite to form _____.

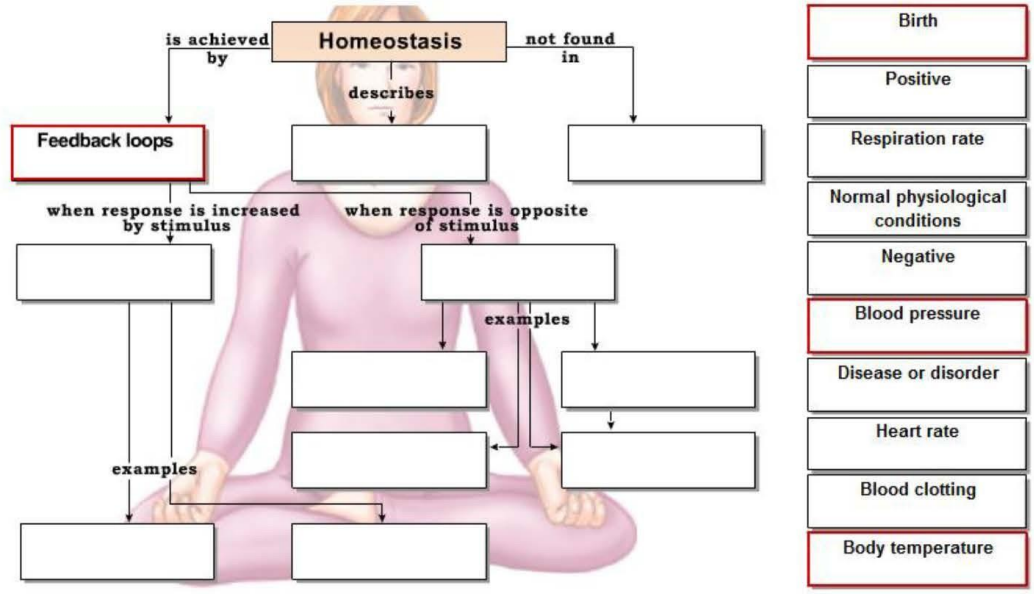
Obj. 1 **10.** At the chemical level of organization, chemicals interact to form complex _____.

Obj. 2 **11.** The homeostatic control that results from the activities of the nervous or endocrine systems is called _____ regulation.

Obj. 2 **12.** When the activities of a cell, tissue, organ, or system change automatically due to environmental variation the homeostatic mechanism which operates is called _____.

Obj. 2. **13.** A response that is important in accelerating processes that must proceed to completion rapidly is called _____.

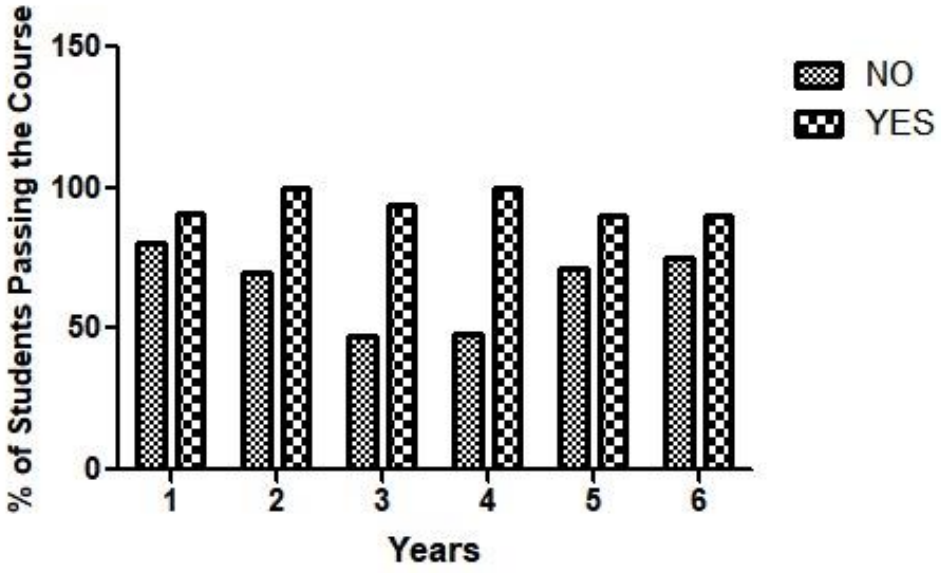
Obj.2. **14.** The two systems usually controlled by negative feedback mechanisms are the nervous and _____ system.



After a brief discussion of the topic, each student's learning outcome (objective) was assessed using a variety of questions on each topic. The lecture was paused, and students worked progressively in two groups to complete each exercise. The lecture would then continue with the following learning objective and then wait again for students to complete the second objective. The cycle was repeated until the end.

Figure 1

Use of Active Learning Worksheets



Pass rates for Anatomy and Physiology I in active learning sections improved consistently over twelve consecutive semesters compared to traditional lectures. The average pass rate is 65.2 (±5.7 SEM) for traditional lectures and 94.2 (±1.9 SEM) for active learning courses, resulting in a difference of 16%. This improvement was statistically significant according to the t-test analysis (two-tailed p = 0.0008; t=4.76 df=10).

Table 1

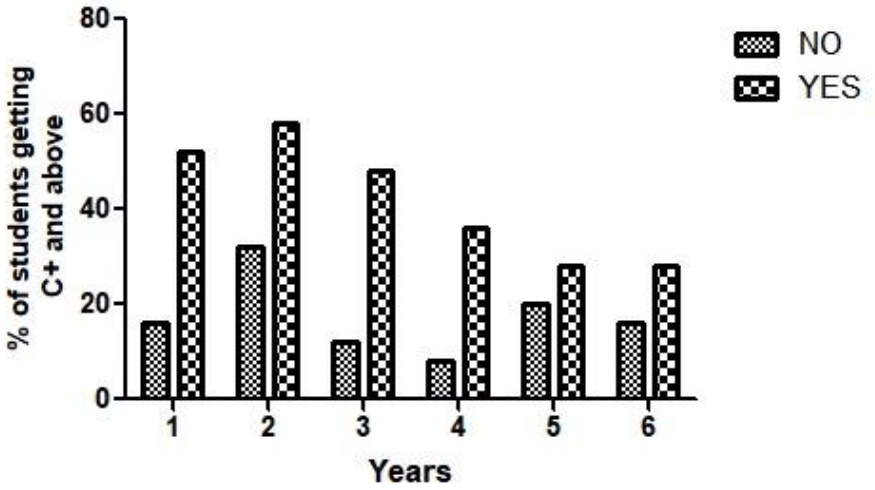
Report on Active Learning with Worksheets

Academic Year	1		2		3		4		5		6	
Use of Active Learning Worksheets	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Number of students	10	21	25	12	17	18	17	11	9	10	12	10
Rate of passing (%)	80	91	70	100	47	94	71	100	78	90	75	90
Rate of grades C+ or higher (%)	16	52	32	58	12	48	20	36	24	28	36	28
Average Course Grade (%)	71	81	69	77	69	78	64	81	81	79	72	79

Data was gathered over twelve consecutive semesters from 172 students, with 82 of those participating in active learning courses. The listed rates represent the percentage of students in each grade group relative to the total student number.

Figure 2

C+ and above Pass Rates



Using active learning worksheets significantly increased the overall number of students achieving a C+ grade over twelve semesters (t-test $p = 0.0029$; $t=3.912$ $df=10$). However, student engagement with these course materials varied across semesters, increasing C+ achievers, particularly in the first four years. The fluctuations are likely attributable to smaller class enrollments in the last four semesters.