Pharmacy Education (2022) 22(1) 647 - 653
https://doi.org/10.46542/pe.2022.221.647653

RESEARCH ARTICLE

A visual thinking strategy enhances an undergraduate human physiology course offered by a Peruvian Pharmacy and Biochemistry School

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Keywords
Evaluation
Kinesthetic
Physiology
Teaching
Visual thinking

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Abstract

Background: This study focuses on enhancing student success in an undergraduate human physiology course offered by the Department of Pharmacy and Biochemistry at the National University of Trujillo (UNT), Peru. This study was motivated by a retrospective view of student performance during the academic years 2008 to 2016, in which only a low percentage of students were able to successfully pass the course. **Method:** In 2017, a questionnaire on visual-auditory-kinesthetic learning styles (VAK) revealed that the predominant learning style among students was visual-auditory. Thus, a Visual Thinking student-centred learning strategy was tested and implemented. **Results:** A noticeable improvement in student success, class participation, and student engagement were observed and linked to the novel learning system adopted. Also, Visual Thinking allowed students to engage in activities that make visible the processes of their creative thinking by laying their ideas graphically, rather than merely showing the conclusions of their thinking.

Introduction

Gaps existing between the proposed learning goals of a course and the actual achievement of these goals by the student must be minimised, particularly in the areas of pharmacy and biochemistry, whose graduates are at the frontline of healthcare. New evidence from diverse branches of science has contributed to a better understanding of what it means to know and the neural events that occur during the learning process (National Research Council, 2000). Studies have also shown that each person has a particular style of acquiring and retaining knowledge and that it is beneficial when a course allows students to engage in distinct cognitive aspects involving reflective, intuitive, verbal, and sequential activities (Gallego, 2013). Several methods have been proposed as ways of enhancing teaching and learning. These include exercises based on class lectures, surveys complementing lectures, monitored excursions, group tasks, practical demonstrations, gamification, concept maps, mock trial, written summary reports and formal group presentations in class (Rosenberg *et al.,* 2018; Whitman *et al.,* 2020) and visual thinking (Hill & Talluto, 2006; Moorman *et al.,* 2017).

The National University of Trujillo, Peru, founded in 1824, established in 1940 the Department of Pharmacy and Biochemistry, which is accredited by the National System of Evaluation, Accreditation, and Certification of Educational Quality (SINEACE). The curriculum track for pharmacy and biochemistry takes about six years to complete. In this context, the human physiology course, which has the human anatomy course as a pre-requisite, is generally taken in the middle of the study plan, about the first term of the third year; it is a required course and a pre-requisite to the pathophysiology course in the fourth year (Institutional Operational Plan Faculty of Pharmacy and Biochemistry. National University of Trujillo. Peru. 2015-2024, 2014). The last term includes a pharmaceutical internship.

The human physiology course offered by the academic department had a high rate (40%) of failed completion among those enrolled, which triggered the motivation to find ways to ameliorate this situation. To that effect, novel teaching strategies were considered to enhance students achieving the course learning goals. After observing retrospectively, the course grades obtained by several generations of students during the academic years 2008 to 2016 (amounting to 1363 entries) showed that only a reduced percentage of students (60%) were capable of passing satisfactorily and advancing in the curricular track to enrol in the sequential pathophysiology course. It was recognized that the manner the course was to be delivered should be student-centred and take into account the input on the learning styles predominant among the students. To this end, a questionnaire was submitted in 2017, which responses indicated that students predominantly preferred a combination of visual, auditive, and kinesthetic forms of learning. Actionable pedagogic changes were carried out based upon these results, which eventually translated into improved average grades and a higher proportion of students successfully achieving the course goals.

Visual thinking has been applied to university-level courses in medicine (Choudhari *et al.,* 2021), nursing (Moorman *et al.,* 2017), and engineering (Felder & Silverman, 1988). Visual thinking involves the extensive reading of course content and drawing visual maps that succinctly present knowledge on the topic (Slota *et al.,* 2018). These visual maps may be posters or infographics with high information content, which design and creation involve several cognitive skills and result in strengthening both the acquisition and the communication of knowledge.

This study presents the results of the implementation of a learning strategy based on visual thinking applied to an undergraduate human physiology course. To the authors' knowledge, the visual thinking strategy has not previously been implemented in this academic institution. The results suggest that accommodating student input and modifying course delivery were beneficial to students achieving the stated course goals.

Methods

Study design

A retrospective characterisation of historical grade data of students enrolled in the Human Physiology course during the academic years 2008 to 2019 was carried out to establish a baseline. A modified VAK questionnaire on visual-auditory-kinesthetic learning styles (Felder & Silverman 1988; Vega, 2010) was applied to all students enrolled in the academic year 2017 before the implementation and the academic year 2019 after the full implementation of the visual thinking strategy to determine the learning style preferred by the students. Data collection was carried out in face-to-face class sessions. The data did not include terms affected by the COVID-19 pandemic.

The practical implementation of the visual thinking strategy started in the first week of class with an explanation to students on how to elaborate the contents of the tasks assigned into mental maps, write relevant texts concisely and clearly, and on techniques such as graphic design, to help visualise a concept. The foundational aspects to work on were explained, providing examples of how to capture the concepts, ideas, and representations of the tasks associated with each learning unit in drawings, texts, and mental maps. Additionally, students were given explanations and tools to present the information in an organised, directed, and synthesised way by these images (Púñez, 2017). The elements used in the tasks were figures in the form of men or women, arrows, geometric shapes, clouds to inform ideas, texts or keywords, organs and systems of the human body, and representative colours, such as red when it came to drawing the blood or blood vessels or the heart. Likewise, students used various stationery materials, markers, and sheets of different sizes and colours for the presentation. The course syllabus demarcated four principal learning units; students were assigned two tasks per unit.

Ethical considerations

Ethical considerations associated with the study were approved by the Institutional Review Board of the Faculty of Pharmacy and Biochemistry of the National University of Trujillo (Resolution No. 46752003106), and prior informed consent was obtained from all student respondents.

Statistical analysis

Statistical analysis and tabulations were carried out using Microsoft Excel. Frequency distributions and analysis of variance were applied to items of the questionnaire. The results obtained from the 2017 data (n=72) were compared to those of 2019 (n=107) using the Mann-Whitney U nonparametric test (alpha level 0.05, two-tail) of the null hypothesis that the responses in both years were similar. Cronbach's Alpha (Cronbach 1951) was used to test the reliability of student responses, which helped assess the consistency of responses across items of the questionnaire.

Results

The present study aimed to enhance the student performance in an undergraduate human physiology course. Results of 1363 students enrolled during 12 years (2008 to 2019) helped establish a benchmark to determine whether the implementation of a visual thinking strategy in 2017 did benefit the students' ability to the course.

Figure 1 shows data between the academic years 2008 and 2016, with a noticeable high proportion of students who were not able to pass the course (above 25%, reaching more than 60% in some cases). However, after applying the visual thinking strategy in 2017 and in subsequent years, the percentage of students failing the course decreased significantly (around 14%).

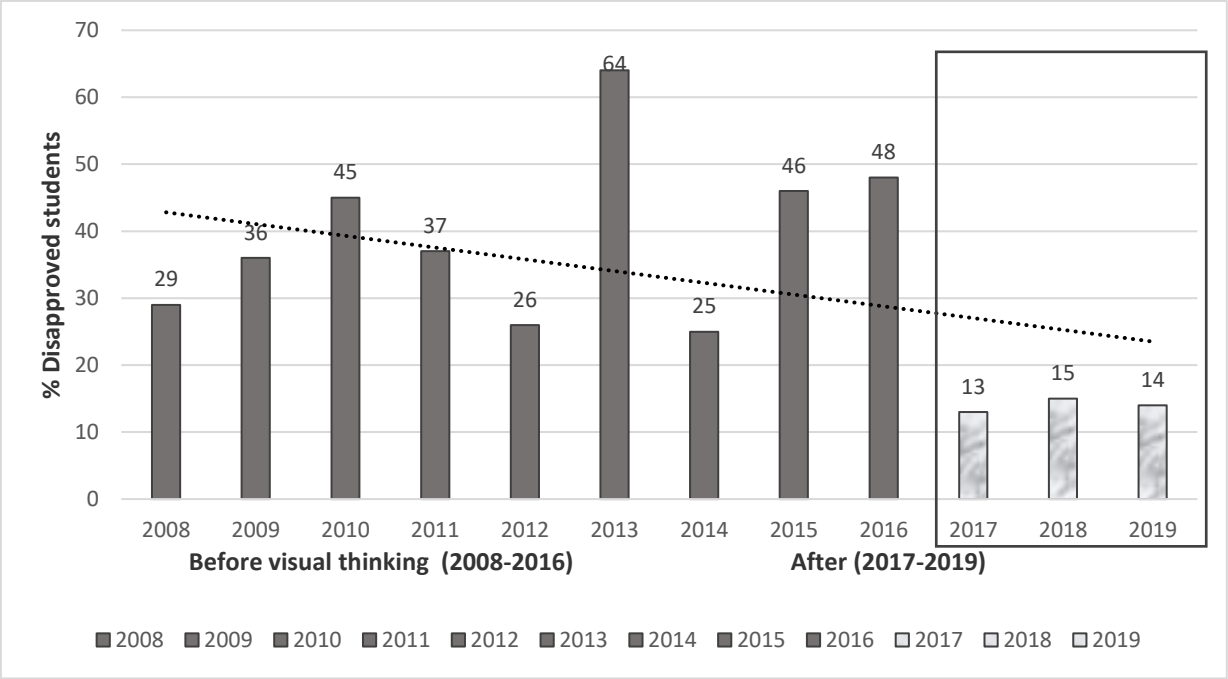

Figure 1: The percentage of student enrollment in the human physiology course before (2008-2016) and after the implementation of the visual learning strategy (2017-2019)

The consolidation of the information collected from the questionnaire's responses of the students is presented in Table I. The questionnaire attempted to inquire what was the manner the students prefer to acquire knowledge. The main finding observed from this table is the predominance of the visual-auditory aspects of learning. The Mann-Whitney U test (Z=-0.083, *p*-value=0.9338) indicated that no significant difference existed between the responses before and after the visual thinking implementation, suggesting that the prognosis based on the 2017 evaluation was corroborated by the 2019 results. The magnitude of the differences between the two groups was small (effect size was 0.49). These results showed the appropriateness of the visual thinking implementation for this course.

The Cronbach's alpha from the 2019 data was 0.84, indicating an acceptable level of internal consistency of the questions and that the responses have a high level of covariance, thus ensuring confidence in inferences drawn from the questionnaire. Hence, the results are consistent with the elements underlying visual thinking among respondents.

Figures 2 and 3 show the effectiveness of the visual thinking implementation in the understanding of the course topics by the students. Regarding the degree of satisfaction, the responses "good" and "very good" predominated for the years 2017 (95%) and 2019 (91%). Also, most students considered that the visual thinking strategy helped them understand the course topics, as seen in responses of "good" and "very good" in 2017 (73%) and 2019 (89%).

Table I: Frequency of student response to the Felder & Silverman questionnaire (1088) employed before (2017) and after the implementation of the learning system (2019)

Questions A = Auditive V = Visual K = Kinesthetic	Percentage of most frequent responses in the years the questionnaire was applied 2017	 2019
1. When you are in class and the teacher explains something that is written on the board or in your book, it is easier for you to follow the explanations:		
A=Listening to the teacher.	**A = 76**	**A = 76**
V=Reading the book or the blackboard.	V = 21	V = 24
K=You get bored and hope they give you something to do.	K = 3	K = 0
2. What distracts you when you are in class?		
A=Noise.	A = 43	A = 45
V=Long explanations.	**V = 50**	**V = 52**
K=Movement.	K = 7	K = 3
3. When they give you instructions. How you behave?		
A=You easily remember the exact words of what they are giving you they said.	A = 28	A = 30
V=You have a hard time remembering oral instructions, but it's okay if they are given to you in writing.	**V = 60**	**V = 60**
K=You get moving before they finish speaking and explain what to do	K = 12	K = 10
4. When you have to learn something by heart. What is your reaction?		
A=You memorize better if you repeat rhythmically and remember step by step.	**A = 49**	**A = 42**
V=You memorize what you see and remember the image (for example, the page of the book).	V = 21	V = 36
K=You memorize by walking and looking and remember a general idea better than details.	K = 30	K= 22
5. What do you like to do the most in class?		
A=That debates are organized and that there is dialogue.	A = 13	A = 27
V=That they give you written material with photos, diagrams.	V = 25	V = 34
K=That activities are organized in which the students have to do things and can move.	**K = 62**	**K = 39**

In bold is the largest percentage

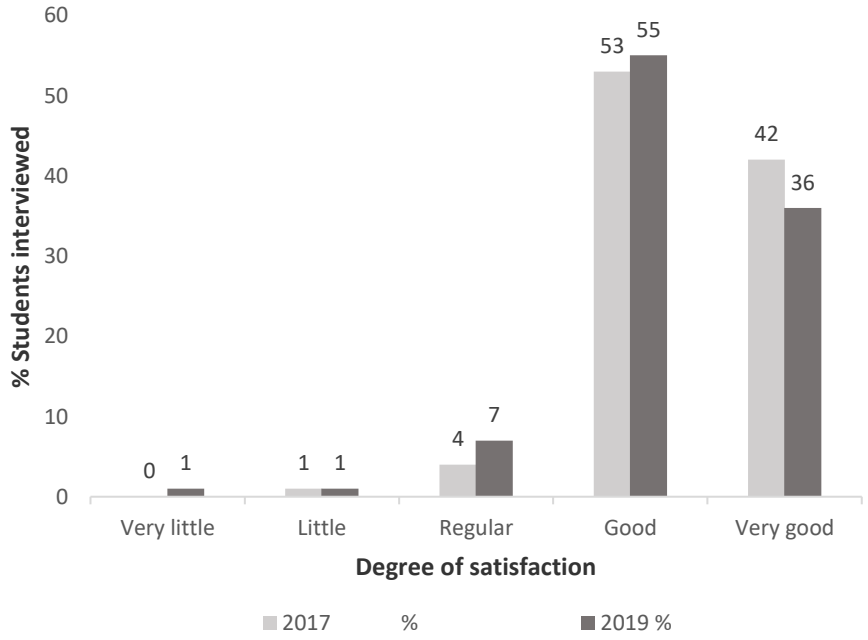

Figure 2: Degree of satisfaction with the visual thinking learning strategy as measured by student interviews at the end of the human physiology course in the academic years 2017 and 2019

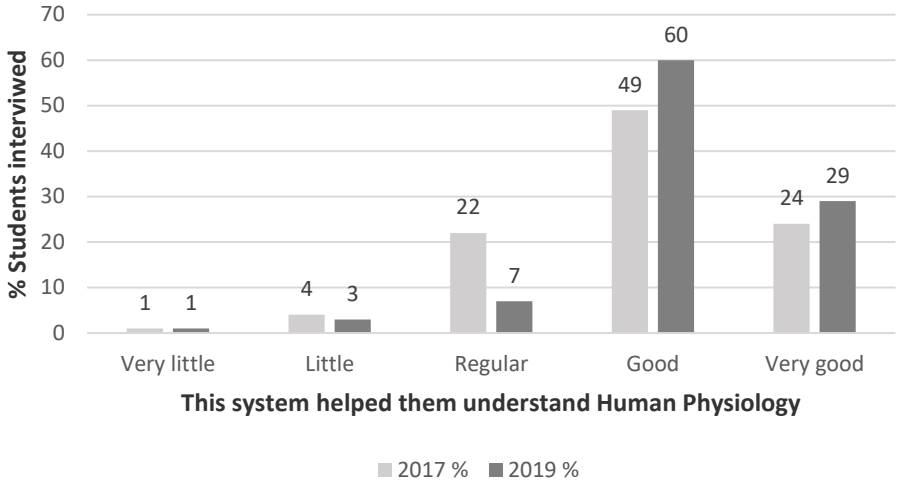

Figure 3: Answers of students to the question of whether the learning system helped them understand better human physiology (academic years 2017 and 2019)

The student input on course evaluation was valued. Figure 4 summarises suggested actions proposed by the students for the enhancement of the visual thinking strategy. It reflects the interest of students in providing input. In 2017, 72% of the students provided suggestions for improvement, while 95% did in 2019.

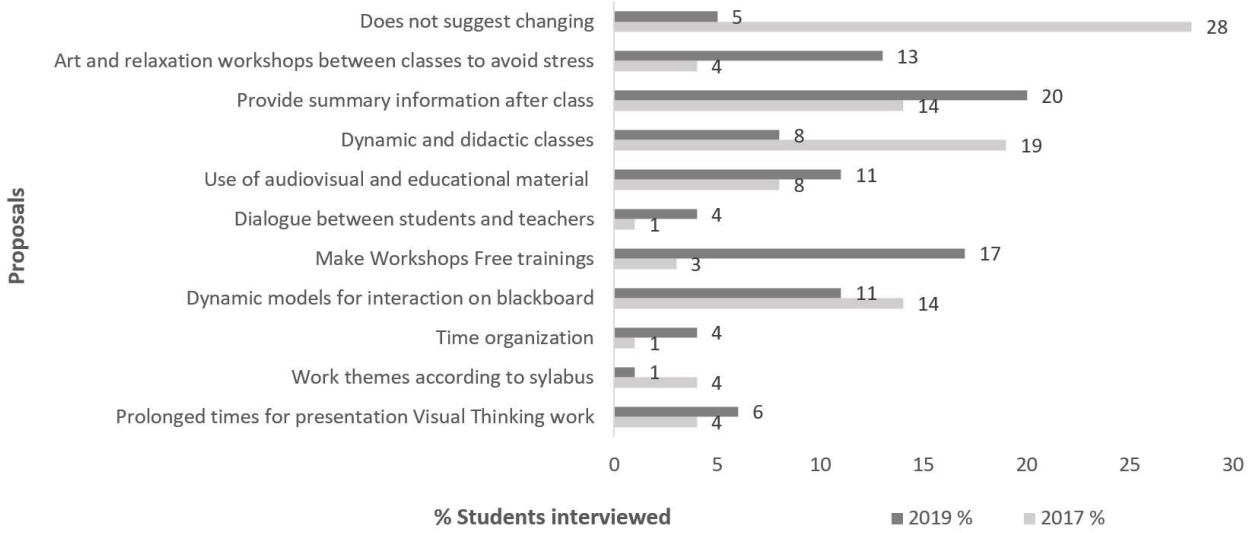

Figure 4: Suggestions offered by the students to improve the learning system

Discussion

This study presents the results of the successful implementation of the visual thinking strategy as a tool to enhance student success in an undergraduate human physiology course. The fact that, at the end of the process, the majority of students were capable of successfully completing the course is an encouraging and desired result. The study showed that the visual thinking strategy was linked to student success and that its implementation had allowed students better recall basic facts, explain ideas or concepts, draw connections among ideas, and produce new, original work, thus

covering several levels of the Bloom's taxonomy of cognitive domains (Bloom *et al.,* 1956). Visual learning involves three main steps, i.e., perception, elaboration, and production (Masi, 2021). Thus, the creation of illustrations such as drawings and graphics leads to the connection of ideas, intuition, focus, incarnation, the translation of experience, and perception. Similar experiences in other academic institutions have also led to innovative course delivery methods. In Qatar, a qualitative content analysis identified gaps between course goals and actual student knowledge in pharmacy courses which compromised the formation of a competent pharmaceutical workforce. It led to the application of corrective interventions in pedagogy of the course (Mukhalalati *et al.,* 2021).

The results of this study agree with those of Choudhari and colleagues (2021), who reported that visual maps facilitate better recall of knowledge by biomedical science students. Su and Long (2021) revealed that teachers in training improved their skills in the construction of their arguments when they were based on visual texts rather than purely conceptual maps. Other similar experiences in novel teaching strategies to improve medical physiology was communicated by Rezende-Filho and colleagues (2014), who allowed students to construct and present physiological-physical models (PPMs), focusing on their potential use in the practice of teaching physiology. Cozine (2019) started with the construction of a database in which, every term, the students expanded by loading human physiological data. This project allowed students to work on various skills, including working as a collaborative team to manage a research project, gaining exposure to retrospective research design, and using fundamental science skills such as written communication and statistics. Other experiences in the human anatomy laboratory, such as the one implemented by Williamson and Lee (2018), emphasised the specific interactions between body systems for common body functions, such as smiling. This linking method utilised several hands-on laboratory activities featuring text, diagrams, and models.

It is observed that students, when given a participating role in the course, take ownership of their learning and display an active interest in the improvement of the course for future terms by providing opinions to educators (Spark *et al.,* 2017). Previous studies have established that the opinions of participants on improving teaching practices do facilitate the creation of a consensus on didactic strategies, aiming to enhance the quality of teaching and learning (Martínez-Sánchez, 2021). Likewise, the emphasis on taking into account the opinion of the students must be recognised overall in courses, especially science courses. To this end, the course must possess avenues where students can communicate freely about their learning styles. A survey among 202 Jordanian pharmacy students found that learning tools and adopting specific behaviours and study habits promoted by their institution's learning centers enhance student performance (Abu Farha *et al.,* 2021).

Conclusion

The design and implementation of the visual learning method improved the success rate of students completing the human physiology course. It is recommended to further consider novel teaching strategies that take into account student input and utilise teaching practices that accommodate the varying student learning styles.

Competing interests

The authors declare no competing interests.

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