Comparing puzzle-based and traditional lecture pedagogies in human anatomy and physiology ii: effects on student performance and intellectual engagement

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Abstract

Most lectures help students learn facts and information but may not train students to use critical thinking and solve problems. Instead, if lessons are designed as puzzles, they give students a broader knowledge framework and help them think deeply which can lead to top marks on subject tests. The study looks at how traditional lectures and exercises using puzzles work compared to each other in the human anatomy and physiology ii laboratory. Students in seven course sections were split so that half followed one teaching approach for the first half, then switched to the other half for the remaining part of the term. The final students were taught the same content but in a reverse teaching order. Assessments of student outcomes included quizzes, exams and in-class homework set up for this research. Assessments looked at how much students can accurately answer questions or draw conclusions, as well as their authentic performance according to education standards. The comparison of results revealed that students did better on standard tests when they were taught with puzzles than when they were taught through traditional lectures. With the puzzle-based strategy, quiz and exam scores were both about 2.1% and 0.4% higher than when using lectures. In brief, student improvement on typical course assessments was noticeable, but more limited when the questions required broad understanding of anatomy and physiology as taught in human anatomy and physiology ii lab.

Key words: puzzle-based pedagogy, lecture-based teaching, human anatomy and physiology, critical thinking, student performance

Introduction

In the last 25 years, studies that compare the usual lecture/memorization/examination model to other teaching methods have suggested that students can become more engaged in meaningful learning [1–5]. Investigations done recently suggest that basic teaching strategies mainly pass along information and fail to stimulate students to use critical thinking and problem-solving [6]. There is a strong emphasis in evaluation on how well non-traditional methods support learning and subject understanding [6, 7]. To learn about links between teaching and students' critical thinking abilities, the study used a measure of real thinking skills developed by researchers [8–13]. The framework looked at five dimensions: thinking skills, depth of understanding, use in real life, important discussions and making learning socially desirable. Experts have already created concepts for project-, problem- and puzzle-based classes, with each technique building on the others [6]. When students use the least abstract approach, they join groups and respond well to unpredictable changes. Also, problem-based learning is used to help students build expertise and reason within set subjects. Unlike other methods, riddles and puzzles in learning help improve understanding and the art of reasoning apart from any particular subject [6, 14–17]. Although project- and problem-based learning have been studied a lot, puzzle-based learning is still less well understood [18, 19]. My aim in this study is to assess how doing puzzles affects important subjects such as class topics and key concepts, as well as useful skills such as thinking in a general way. Other than traditional lecturing, learning by heart and exams such education styles involve students in classroom actions that exercise various intellectual abilities used in many fields [20–22].

When students participate in puzzle-based classroom tasks, they use their past information, express answers clearly, grasp and work with new facts and develop their thoughts [4, 5]. The research goal was to analyze the impacts of both kinds of teaching strategies on actual thought process and educational outcomes.

Methods

Because research with human participants was identified as having no risks, used regular practices and respected participant anonymity, the institutional review board exempted it from prior notice and approval. Students currently in the human anatomy and physiology ii laboratory course participated in the study. In all, 185 students in seven sections learned using classic techniques as well as puzzle solving methods. Their real academic skill was tested, as well as the typical course grades they received. The three sections were teaching using two teaching assistants. Before studying nursing, pre-medical studies, exercise science, biochemistry or biology, students must complete the human anatomy and physiology ii laboratory. While we did not control the number of students in each major, we noted which field every student intended to study to check for any bias in the programs. As no bias was present, this research method was dismissed from the final analysis.

Research using a single-subject crossover design

To conduct this research, all course material had to be scheduled so that topics prior to the midterm were more difficult and those after the midterm were less demanding. It means that it's possible for scores near the end of the semester to rise by luck, even with unchanged teaching methods, simply because the work covered is simpler. For this reason, a single-subject crossover design was chosen (see figure 1). Two sections were each taught by a teaching assistant using a puzzle-based approach until after the midterm practical, after which they shifted to using lectures. Most of the material was presented with lectures at first and after midterms, efforts shifted to using puzzles and activities. The design enables us to test if using various teaching styles in different order affects student achievement, showing the anticipated bias in favor of higher scores at the end of the semester. This research also allows for determining if teaching style plays a major role in learning outcomes regardless of order. As a result, when teaching style and order matter, better performance in the late stages of the semester comes from both simpler coursework and the lessons learned in class.

The old lecturing method

I used a presentation software and a projector for the discussion portion which helped me share key information and pictures relating to the week's lab. The teaching assistant used material from their notes to help explain the points shown in the slides (an example of a slide and their notes are both shown in figure 2). The students followed the lecture with a prelab activity (see figure 3), where they used their lab manuals and the models in the classroom to complete about a dozen questions. The students were further required to mention some ways the week's concepts relate to real situations, as a sign of genuine thinking ability. For every image in the lab manual, attendees could use the real anatomical displays shown throughout the session. Students were graded on their accuracy for pre-lab homework and the results were given back to support their continued study.

Puzzle-based design

Information specific to a problem and ideas that apply in general

Unlike problem- or project-based approaches, puzzle-based methods aim to improve a person's abstract reasoning and general critical thinking [6, 16, 17]. This form of teaching is

not only introducing solutions to many puzzles, but also applies puzzles as examples to explore wide-ranging problem-solving approaches and the required concepts [6, 17]. This study used both the human anatomy and physiology ii lab and puzzle-based designs to teach reasoning skills that can be used in several areas. The material for participants often started with "rules" that explored how the ideas could be applied in medicine.

Results

Table 1. Manova comparing scores on standard assessments between pedagogies

Effect	Wilks' lambda	F	Hypothesis df	Error df	P-value
Teaching style	0.92	6.230	3	298	0.0008*
Order	0.90	10.412	3	298	0.0001*
Teaching style + order	0.85	14.755	3	298	0.000*

Table 2. Manova comparing scores on standard assessments between pedagogies with tests for between-subjects effects on quizzes and tests

Multivariate tests	Between subject effects
Effect	**Wilks' lambda**
Teaching style	0.93
Order	0.89
Teaching style + order	0.82

Table 3. Manova comparing scores on standard assessments between pedagogies for ta1 and ta2 with tests for between subject effects on quizzes and tests

Multivariate tests	Between subject effects
Effect	**Wilks' lambda**
	Ta1
Teaching style	0.96
Order	0.94
Teaching style + order	0.88

Figure 1: manova results: f-statistics by effect, all effects significant at p < 0.001 (df = 3, 298)

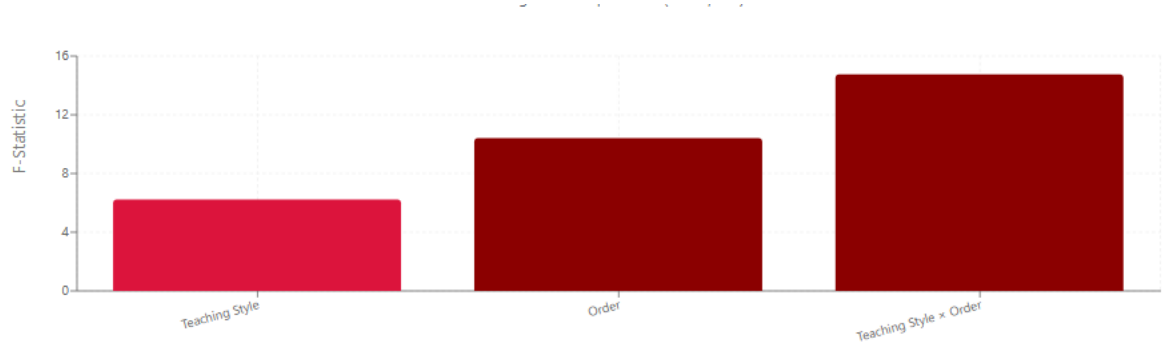

Figure 2: manova results: wilks' lambda values, between-subjects effects on quizzes and tests (lower values = stronger effects)

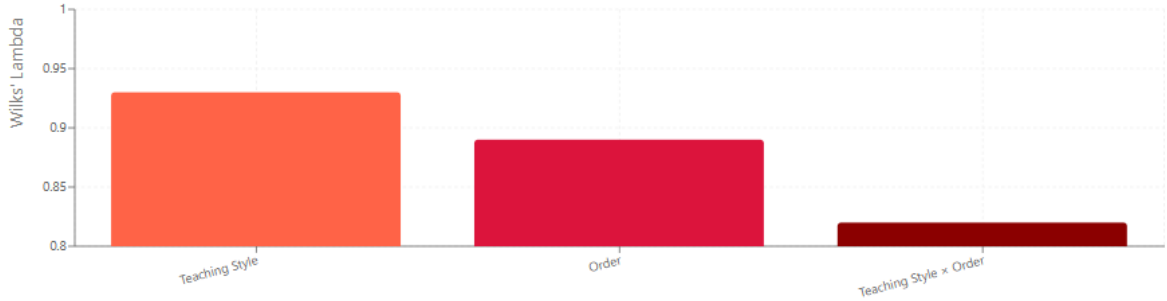

Figure 3: manova results: ta1 analysis, wilks' lambda for between-subjects effects (lower values = stronger effects)

To assess how student performance varied in standard tests, manova was used to analyze the differences between teaching with puzzles and traditional lectures. Manova results, found in table 1, show that teaching style, order and how they interact impacted students' learning. The lambda values at 0.92, 0.90 and 0.85 and the f-values between 6.230 and 14.755, alongside very significant p-values, indicate that teaching style and its sequence strongly affected the students' scores. It demonstrates that teaching methods and the timing of those methods can both shape the outcomes of learning. Table 2 then explores the separate effects of teaching style, order and their interaction on quizzes and tests. The results from the wilks' lambda tests for every model are statistically significant which agrees with the first findings. It shows that both quizzes and tests can be changed by changes in the way teaching is arranged, proving the impact of teaching methods on each assessment type. In order to investigate if instructor-related variables contribute, table 3 breaks down data for two

teaching assistants (ta1 and ta2). Both ta1 and the amount of orders received continue to affect grades and this influence does not appear to vary by instructor. Therefore, the success of a student's academic achievements appears to depend on the instructors' teaching style and its timing, aside from who is teaching the material. All things considered, these studies point out why instructors need to pay attention to applying puzzle learning and to planning when to deliver lessons to support students' academic performance and results on assessments.

Discussion

When we look at all the results, comparing puzzle-based methods with lecture-based ones suggests that puzzle pedagogy can be considered at least as effective as other similar approaches in providing experiential or open learning [8]. Before, researchers have stacked the evidence for open or experiential learning through puzzles in subjects like math and computer science [6, 16, 17]. This study introduces "open/experiential" learning into a human anatomy and physiology ii lab where, typically, students are mostly taught with dry descriptions that require rote memorization. Introducing "open/experiential" learning to this area of study supports the idea offered earlier, based on research, that puzzle- and problem-based learning works effectively in many areas [8]. Metrics show that using puzzle-based teaching leads to much stronger results on standard laboratory tests than lectures do. Even so, the importance found in true intellectual performance tests is not always obvious and may be unreliable. A likely reason for better results on standard assessments is that the puzzle-based approach puts things in context, helping students remember details better. It has also been shown in related fields that teaching abstract concepts by using puzzles can improve how well students understand such topics [6, 16, 17]. Unlike what is expected in the first and second labs, the third anatomy and physiology lab has a major focus on memorizing structures, rather than truly understanding concepts. While the material in these lessons and methods of assessing it are different from prior courses, the use of puzzle learning seems to lead to stronger retention and better results for students when compared to just lectures.

How characteristic traits of an instructor influence students

One clear finding from the study is that student performance was strongly influenced by the teaching assistant's own traits. Being familiar with the course material, friendly and responsive in class probably helped them. Although neither teaching assistant had earlier taught or structured puzzle activities for this course, the one with prior knowledge of the course helped plan activities in class. Although both assistants worked hard to be consistent, the more experienced one might have been able to lead students in understanding the subject better thanks to their familiarity. The participants reported feeling frustrated because the assistant with less experience did not engage well in the activities.

Getting excited about what you need to achieve

Students in this course know that anatomical identification and memorization are essential parts of the class. It appears from various reflective stories that many students felt that puzzle activities were too challenging and not very useful for their education, while they often view anatomy and physiology as merely a set of facts to memorize. Some studies before saw puzzle-based learning as stimulating and pleasurable [6, 17], whereas the one in this study did not. All the participants had gone through the entire sequence so far, as they were not required to complete puzzle activities which likely made the additional puzzles in this study seem overly demanding for some and caused some resistance. It was easier to see this resistance in how little students engaged with true tests of their knowledge and abilities. Many students believed the hard work given to these assessments did not deserve the little credit they received, so they either put in little effort or completely skipped some

assessments, often right after a memorable dbt puzzle. The results for the assignment of incomplete problems (aip) show that learners with puzzle instruction had more blank answers (30.2%) than those with traditional instruction (14.5%). Because aip declines slowly over the years, some researchers limit aip test use to once each semester [10]. According to these findings, using aip assessments is only effective at measuring broad conceptual understanding in a few contexts and won't suit the laboratory setting. On the other hand, useful data may be obtained with few tests or less seemingly hard work by students. Doing this study early in the sequence, when students haven't experienced as much in other lessons, may encourage them and show the benefits of using puzzles more clearly.

Conclusion

Like other studies before us, our findings demonstrate that teaching approaches greatly affect student success. The research adds to the consensus that placing information into context can make it easier for learners to remember, but also notes that a teacher's unique traits play a big role in the impact of teaching. Our study reveals that there is no broadly used tool that accurately assesses expansive understanding of concepts covering different academic fields. Ultimately, students who use puzzle-based instruction tend to score better on assessments, even though those assessments mainly test for basic understanding of the subject.

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