Lectures and collaborative working improves the performance of medical students

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Abstract

The teaching-learning process is complex and requires continuous research and dedication. Research has been important to prove that student achievement can improve when active methodologies are properly implemented, either in isolation or integrated with a short lecture. The purpose of this work was to evaluate the performance and perception of first-year medical students subjected to a protocol involving the integration of a short lecture and collaborative compilation of portfolios on the topic of digestive physiology. After the lectures and elaboration of the portfolios, the students completed two tests: cognitive monitoring test (CMT) and integrative cognitive test (ICT), and then, they gave their opinions of the strategy. For CMT, the percentage of grade exceeding 7.0 was higher for the group who performed the portfolio activity, compared with the group who did not undertake the activity, and there was a lower percentage of incorrect answers among the portfolio group students, compared with the group that did not perform the activity. For ICT, the percentage of grades exceeding 7.0 was higher for the students who used the portfolio, compared with those who did not perform the activity, and there was also a reduction in incorrect answers among students who performed the portfolio activity, compared with those who did not perform the activity. The combination of short lectures and collaborative group work using a portfolio improved the grades obtained for digestive physiology. Most of the students believed that the collaborative work contributed to their learning about digestive physiology. In addition, most of them were comfortable working in their groups and did not feel dominated by other group members.

active learning; collaborative working; physiology; portfolio; short lecture

INTRODUCTION

Innovations in education are essential for solving problems and introducing new ways of teaching, learning, and thinking. However, the implementation of these innovations must take several factors into consideration, including the context, the environment, the technology needed, the cost, and the pace of implementation (1). The education literature challenges teachers to be more creative and innovative in their active learning classes (2–5). In cooperative learning, the acquisition of knowledge is achieved proactively, involving social interaction among people, so students must play active roles, and become engaged in their own learning (6, 7).

Selection of the pedagogical methodologies to be used in the curriculum should be performed with due care, so that both teachers and students can obtain the maximum benefits from these techniques. In our medical curriculum, the physiology course is offered in the first three semesters. Physiology courses are considered complex, but also very interesting (8), so we made a careful evaluation of the material that the students would be expected to learn, as well as the specific challenges for enhancing their learning of physiology mechanisms. Furthermore, teachers should be able to design their strategies, so as to improve buy-in from both students and other faculty members (4).

The classroom can and should be a laboratory where personal educational philosophies are tested, evaluated, and refined (9). Studies have indicated that active forms of learning can be more effective than traditional lectures (5, 10–13). However, this does not mean that traditional classes are unsuitable; they are important and should be used (14–17). Accordingly, a combination of active learning and traditional lectures can be an excellent option.

Active learning methodologies, such as those that involve collaboration, have been found to provide desirable positive effects. These include improved self-perceived competence (18), student engagement in the learning process (10, 18, 19), enhanced problem-solving skills, collaborative discussion of information, and working as a team to accomplish a task (11, 19–22). Therefore, the aim of this study was to analyze the performance and perception of medical students who were submitted to a regime comprising shorter theoretical classes together with groups working to produce portfolios.
### METHODS

**Setting**

The activities were carried out with first-year medical school students ($n = 100$). For this trial, the duration of each lecture was reduced from 90 min to 40 min. There were three lectures (120 min) on digestive physiology, which were presented on three different days in two consecutive weeks. The activity performed was about digestive physiology, specifically motility, secretions, and the digestion and absorption of carbohydrates, proteins, and lipids. The division of subjects was carried out according to the medical course curriculum.

**Portfolio about Digestive Physiology**

The portfolio activity for the digestive physiology discipline followed the organization described in our previous article (22), with adaptations. Briefly, first-year students (second semester) were divided into 25 groups ($n = 3$ or 4 students per group) for the three gastrointestinal modalities: motility (eight groups), secretion (eight groups), and carbohydrates, proteins, and lipids digestion and absorption (nine groups). The composition of each group was determined by the students themselves. However, on the basis of student performance and engagement working in groups from the previous semester, the teacher supervised the formation of the groups, so that there were no groups formed by only engaged students with the best performances, and other groups formed by only less engaged students with the lowest performances. The students from each group then gathered for 60 min to organize the portfolio ideas. Afterward, the teacher held 30-min meetings with the student groups, broken down according to the modalities described above, and 30 min to finalize the organization of the portfolio topics (Table 1). This activity step was performed in 120 min.

The next step was to define the formatting of the portfolio, so that all the groups presented it in the same format. It was established that the topics of each modality should be presented in up to 2 pages (A4, 210 × 297 mm), with Times New Roman font, font size 11, and 1.5 line spacing. It was also established that the portfolio could contain texts, figures, photographs, diagrams, and tables, according to the group’s decision. For example, the gastrointestinal motility modality could have up to 12 pages, with 2 pages for each proposed topic, while the gastrointestinal secretional modality could have up to 10 pages, and so on (Table 1).

The time available for the activities was 9 h (3 h per week, for three consecutive weeks). At all times, the lecturer was present to assist the students, if requested.

At the end of the portfolio preparation, the students were instructed to exchange portfolios between groups, according to modality differences. The main purpose of this was to ensure that all of the students had exposure to all of the topics in the modalities about digestive physiology. In this way, all the students had full access to the digestive physiology content and were able to study for the assessments.

**Assessments**

The evaluation system of the medical school consisted of bimonthly assessments: theoretical background, skills and competency, and profile. The student needed to achieve a score of 7.0 (out of 10.0) in all the assessment items, in order to proceed to the next semester of the medical course (13). The theoretical tests included a cognitive monitoring test (CMT) and an integrative cognitive test (ICT). After performing the activities described above, evaluation was made of the performance of the students in these tests concerning the digestive physiology topics.

**Cognitive monitoring test.**

The CMT was composed solely of physiology issues. The questions were of low complexity, and the test was used to provide the lecturer with rapid feedback on student performance. It consisted of five multiple-choice questions (MCQs) related to the digestive physiology topics organized in the portfolio, and the response time allowed was up to 15 min. The CMT was held one week after delivery of the portfolios, and it was performed individually.

**Integrative cognitive test.**

The ICT used clinical cases to contextualize the topics studied. In order to answer the questions, the students had to read the proposed clinical case. This test considered all the courses taken by the students in a given semester. The questions in the ICT were of higher complexity, compared to the CMT. On average, the ICT consisted of a total of 40 questions (written answer, MCQ, and association questions). The main purpose of this test was to analyze the student’s overall performance during the semester. The physiology questions for this test considered the digestive (four questions) and respiratory (three questions) systems. However, for the present study, only questions about digestive physiology were analyzed. The value of the physiology in the ICT is 2.0 out of 10.0. Therefore,

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### Table 1. Description of topics organized for each modality of the digestive physiology portfolio

| Modalities                  | Topics                                                                 |
|-----------------------------|------------------------------------------------------------------------|
| Gastrointestinal motility   | Describe the physiological importance and main mechanisms of neuroendocrine movement controls for: |
|                             | • oral cavity: chewing and swallowing;                                  |
|                             | • esophagus: peristalsis;                                               |
|                             | • stomach: mixing (churning) and emptying;                             |
|                             | • small intestine: peristalsis and segmentation;                       |
|                             | • large intestine: peristalsis, mass peristalsis, and haustrations;    |
|                             | • defection and vomiting reflexes.                                     |
| Gastrointestinal secretions | Describe the main components, the main physiological actions, and the neuroendocrine control mechanisms of the synthesis and release of: |
|                             | • saliva secretion;                                                    |
|                             | • gastric secretion;                                                   |
|                             | • liver secretion (bile);                                               |
|                             | • pancreatic secretion;                                                |
|                             | • intestinal secretions;                                               |
| Digestion and absorption    | Describe the main digestion and absorption mechanisms, the main enzymes involved in the digestion mechanisms, and the main absorption sites for: |
|                             | • carbohydrates;                                                      |
|                             | • proteins;                                                            |
|                             | • lipids.                                                              |
it was considered that 2.0 in the ICT, related to the physiology of the digestive system, was equivalent to 10 points. There were four questions, so the value for each question was 2.5. Like the CMT, the ICT was answered individually by the students. The response time allowed for this test was up to 4 h. The ICT was held 10 days after the CMT tests.

Questions Answered by the Students after the Portfolio Activity

On the day the students finished and delivered the portfolio, they were individually and anonymously asked four questions concerning their interaction within the group and their perceived benefits of the activity, as shown in Table 2 (23, 24). The Likert-type scale (from strongly agree to strongly disagree) was used for students to answer the questions.

Experimental Protocol

Students in the second semester of the first-year of the medical course considered the cardiovascular, digestive, and respiratory systems. For the present study, the results for the 2019 first-year students, who performed the digestive physiology portfolio activity, were compared with those for the 2018 first-year students, who did not perform the activity. The 2018 student took exactly the same digestive physiology activity, improved student performance in learning about digestive physiology.

The 2018 student performed the digestive physiology portfolio activity, were compared with those for the 2019 students. Therefore, there was no bias in the digestive physiology contents presented to the first-year students in either 2018 or 2019.

The CMT and ICT tests performed by the students from years 2018 and 2019 had the same number of questions, the same question types (written answer, MCQ, and association questions), and the same complexity, and the students had the same time to answer the tests. A similar protocol was presented by Luchi et al. (12). Therefore, the only difference between the classes (comparing years 2018 and 2019) was the portfolio group work activity.

The lectures and tests were prepared by the same teacher, for both 2018 and 2019 classes. Hence, the hypothesis adopted was that the elaboration of the portfolio, as a group activity, improved student performance in learning about digestive physiology.

All of the students agreed to participate, they gave informed consent authorizing the dissemination of the results. The activities were carried out under the responsibility of the lecturer of the Biophysics and Physiology-II discipline and were authorized by the coordinator of the medical course at the university.

Statistical Analysis

The $\chi^2$-test was used to compare the CMT and ICT test grades obtained by the 2019 students ($n = 100$) with those of the 2018 students who did not perform the activity ($n = 53$). Comparison was also made of the number of incorrect answers in the CMT and ICT tests for the students who did and did not perform the activity. The criterion used was a score of 7.0 (out of 10.0), because this was the minimum grade required for the student to proceed to the next stage in the medical course. The results were reported as means (SD). Significant statistical differences were considered for $P$ values < 0.05.

### RESULTS

One hundred students participated in the portfolio activity (Class 2019), consisting of 67 (67%) women and 33 (33%) men, with an average age of 20 years. Fifty-three students (Class 2018) did not perform the activity, consisting of 39 (74%) women and 14 (26%) men, with an average age of 19 years.

Table 3 shows the grade percentages obtained in CMT and ICT tests for the students who did and did not perform the portfolio task. In the case of the CMT test, use of the portfolio had a significant effect on the student’s grade. The percentage of grades exceeding 7.0 was higher for the group who performed the portfolio activity (71%, $P = 0.013$), compared with the group who did not undertake the activity (34%, $P = 0.014$). The use of the portfolio task also significantly improved the grades in the ICT evaluation, with the percentage of grades exceeding 7.0 being higher for the students who used the portfolio (52%; $P = 0.013$), compared to those who did not perform the activity (38%; $P = 0.012$).

Table 4 shows the percentages of incorrect answers in the CMT and ICT for the students who did and did not perform the portfolio task. For the CMT, there was a lower percentage of incorrect answers among the portfolio group students (4%; $P = 0.013$), compared to the group that did not perform the activity (35%; $P = 0.02$). There was also a reduction in incorrect answers for the ICT among students who performed the portfolio activity (6%; $P = 0.012$), compared to those who did not perform the activity (42%; $P = 0.011$).

### Questions Answered by the Students after the Portfolio Activity

As shown in Table 5, 97% of the students have friends in their working groups. Sixty-seven students (67%) worked...
comfortably with members of their group (Strongly Agree: 10%; Agree: 42%; and Somewhat Agree: 15%), while 33% of the students did not feel comfortable in their groups (Somewhat Disagree: 17%; Disagree: 9%; and Strongly Disagree: 7%). Most of the students (88%) did not feel that the discussions were dominated by a particular member of the group. Finally, 88% of the students manifested a positive perception of the portfolio, in terms of their learning (Strongly Agree: 74%; Agree: 6%; and Somewhat Agree: 8%). On the other hand, despite being a minority, 12% of the students had a negative perception of the effect of the activity on their learning about digestive physiology (Somewhat Disagree: 2%; Disagree: 6%; and Strongly Disagree: 4%).

**DISCUSSION**

The benefits of using cooperative learning techniques in teaching activities have been documented (6, 25–27), but few studies have analyzed the factors affecting students’ achievement (28, 29). Goodman et al. (4), evaluated what physiology students should be expected to learn, together with the specific challenges involved in enhancing their learning of physiology principles using various types of active learning, as best practices for evidence-based teaching. It is clear that the choice of an active methodology and the implementation of collaborative group working must be aligned with the course curriculum. The objectives of this implementation must be clearly defined, and the use of such methodologies must be clearly explained to the students. Above all, teachers must be able to apply them.

For some years, we have been working with active methodologies in the physiology courses of the medical curriculum (13, 15, 22, 30), as well as in other health areas such as dentistry, pharmacy, physiotherapy, and nursing (20, 31–33). Benade (34) suggested that individual reflection has little relevance beyond narrow workplace requirements, and that learning is becoming increasingly collaborative and acquiring a temporal character. It must consider the relationship between the teacher and the students, the students’ learning approaches and motivations, supportive learning technologies, the teaching and learning environment (and the students’ perceptions about it), and the potential link with the learning outcomes (6, 21, 35, 36).

The results of the present work show that the choice of reduced classical lectures associated with collaborative work involving the elaboration of a portfolio, with well-defined modalities and topics (Table 1), was a good strategy for the teaching and learning of digestive physiology applied to the first-year medical students. Thus, the strategy of short traditional lectures associated with an active methodology was able to improve the students’ understanding of digestive physiology. This was evidenced by the improvement in the test scores and by the decrease in the number of incorrect answers provided by the students who performed the portfolio activity. The portfolio method, as well as other active teaching strategies (11, 12, 31, 32, 37–39), can increase the students’ interest and knowledge retention, promote interaction among the students, and stimulate problem-solving.

There are often tensions related to innovation and the implementation of new pedagogical activities in different areas, requiring consideration of the evidence for the benefits of the innovation, in light of the available resources and readiness for change. Resolution of tensions depends on achieving a balance between the local context and the potential advantages brought by the strategy (1). In the present case, the results demonstrated that the implementation of an active methodology associated with reduced duration of classical lectures, did not create any tensions among either

| Table 4. Incorrect answers in the CMT and ICT obtained by first-year students who did (n = 100) and did not (n = 53) perform the digestive physiology portfolio activity |
|------------------------------------------------------------------------------------------|
| Students without Portfolio | Students with Portfolio |
|-------------------------------|------------------------|
| CMT incorrect answers, % | 35 (4) (P = 0.02) | 4 (1) (P = 0.013) |
| ICT incorrect answers, % | 42 (3) (P = 0.011) | 6 (1) (P = 0.012) |

The data are shown as mean (SD). Significant difference (P < 0.05): CMT, cognitive monitoring test; ICT, integrative monitoring test.

| Table 5. Response percentages for questions individually answered by the students (n = 100) after the portfolio activity |
|------------------------------------------------------------------------------------------|
| **Answers** | |
| Are you friends with at least one person who was in your group? | Yes: 97%  |
| No: 3% | |
| I felt comfortable with my group. | Strongly Agree: 10%  |
| Agree: 42% | Somewhat Agree: 15%  |
| Disagree: 9% | Strongly Disagree: 7%  |
| One group member dominated discussion during the portfolio activity. | Strongly Agree: 2%  |
| Agree: 2% | Somewhat Agree: 8%  |
| Disagree: 64% | Strongly Disagree: 19%  |
| The activity contributed to my learning about digestive physiology. | Strongly Agree: 74%  |
| Agree: 6% | Somewhat Agree: 8%  |
| Disagree: 2% | Strongly Disagree: 4%  |

| Table 3. Percentages of grades in the CMT and ICT evaluations for the first-year students who did (n = 100) or did not (n = 53) perform the digestive physiology portfolio activity |
|------------------------------------------------------------------------------------------|
| | Students without Portfolio | Students with Portfolio |
|-------------------------------|------------------------|
| CMT Grade < 6.9 (%) | 66 (3) (P = 0.012) | 29 (2) (P = 0.015)* |
| CMT Grade > 7.0 (%) | 34 (1) (P = 0.014) | 71 (4) (P = 0.013)* |
| ICT Grade < 6.9 (%) | 62 (2) (P = 0.014) | 48 (3) (P = 0.016)* |
| ICT Grade > 7.0 (%) | 38 (4) (P = 0.012) | 52 (3) (P = 0.013)* |

The data are shown as mean (SD). *Significant differences (P < 0.05): CMT, cognitive monitoring test; ICT, integrative monitoring test.
the students or the teacher. During the time that the students were working on portfolios in their groups, it could be observed that there were positive interactions among them and that they seemed to be enjoying the activity. This was important, since the performance of students can be improved when the learning process is associated with a sense of pleasure (30, 40, 41).

There is scientific evidence that working in groups can have beneficial effects on student learning (11, 20, 25, 26, 37, 42). Collaborative learning techniques provide opportunities to improve the student’s self-regulated behavior and reduce anxiety (6, 43), while promoting more interdependent relationships among students and between students and lecturer, stimulating interest, and producing better learning and teaching outcomes (44–46). The students play an active role, so they are more proactive and more engaged in the learning process (29), having responsibility for the learning of others and being more creative (6, 47). The engagement of students and lecturers as partners is a multidimensional process involving the development of medical knowledge, skill, and attitudes (44, 48, 49). Following this line of reasoning, the results presented here showed that most of the students had a positive perception of group working. They also felt that the working environment was friendly, comfortable, and without any negative dominance of particular individuals. Furthermore, the use of the group activity resulted in improved performance of the students in the digestive physiology tests.

Limitations

The main limitation of this study was that the control and portfolio groups were not from the same class of students. Because of the schedule of classes for the semester, it was not possible to apply the group activity for two groups in the same class. No major differences were identified between the classes compared (from year 2018 and year 2019), except for the portfolio activity and the lecture duration, without any bias in the topics studied.

The tests between years were prepared with the intention of equal difficulty based on the author’s sole judgment. In the present work, nine questions related to digestive physiology were used, four questions from the ICT and five questions from the CMT.

Conclusions

The use of short lecture classes associated with collaborative group working involving the elaboration of a portfolio, with well-defined modalities and objectives, improved the students’ grades and decreased the percentage of incorrect answers in bimonthly tests. Most of the students believed that the collaborative work contributed to their learning about digestive physiology. In addition, most of the students reported being comfortable working in their groups, without feeling dominated by other group members.

DISCLOSURES

No conflict of interest, financial or otherwise, are declared by the author.

AUTHOR CONTRIBUTIONS

L.H.M. conceived and designed research; L.H.M. performed experiments; L.H.M. analyzed data; L.H.M. interpreted results of experiments; L.H.M. prepared figures; L.H.M. drafted manuscript; L.H.M. edited and revised manuscript; L.H.M. approved final version of manuscript.

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