EVALUATION OF THE IMPLEMENTATION OF THE STRATEGY OF PROBLEM-BASED LEARNING (PBL) IN DIGESTIVE SYSTEM PHYSIOLOGY TEACHING


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Abstract

As a basic science discipline of the Pharmacy curriculum, Physiology could be used as a starting point with respect to incorporating clinical relevance as well as developing problem-solving skills of the pharmacy student. PBL methodology makes students more creative and constructive and helps them to develop knowledges, skills, behaviours, and attitudes that prepare them in their professional life to be good practicing pharmacists. Our current practical Physiology program provides students with the opportunity to gain a first-hand laboratory experience of the structure, function, and development of the digestive system. By using of both the simulation PhysioEX 9.0 software as a virtual laboratory and the histological analysis of the digestive structures, students learn to integrate human anatomy and physiology. In this study, a mixed-methods approach was adopted including PBL as a planning practical course strategy. We compared the degree of satisfaction and academic achievement of students from second-year pharmacy students enrolled in the practical physiology course, one group including problem-based learning (PBL) and another one without PBL (Non-PBL) method. Students performed the tasks in small groups of 3-4 students. All of them used the simulation virtual laboratory where they evaluated the activity and function of the digestive enzymes and also carried out the histological study of the different areas of the digestive system. For the PBL group, a case problems were designed and delivered in the Virtual Campus with enough time for its completion by self-learning using students own bibliography. During the practical session, the students with PBL clarified case-problem terms with a brainstorm about the possible explanations, identified learning solutions and questions and the subsequent discussion to integrate the individual results from their self-study with those found from simulation and histological analysis. The non-PBL students were enrolled in the traditional class conducted by lectures. Student feedback was received based on a questionnaire in the five-point Likert scale format. The satisfaction questionnaire evaluated and compared the opinions of the students in ten fields of learning and the interaction between the applied learning methods. The feedback revealed a majority agreement that PBL helped students create interest, better understanding and promotes critical thinking. Cronbach’s alpha reliability coefficient were 0.825 (PBL) and 0.929 (not PBL), respectively. The results of our study clearly showed that PBL condition had significantly higher mean scores. In addition, to evaluate whether the mixed PBL method helped to solve the posed clinical case-problems, Pre and Post-test score statistical analysis was performed. A substantial improvement in post-test results clearly revealed PBL’s acceptance. Students learned to correlate relevant enzymatic mechanisms, histological, and clinical features with the clinical signs and symptoms, to learn the digestive physiology. PBL integrated with conventional learning methods would be more effective at helping student to learn and to have an integrating vision of the functioning of the physiological systems which can be applied in the professional context as future pharmacist.

Keywords: Problem based learning, Physiology simulation, Histological analyses. Virtual Campus.

1 INTRODUCTION

Nowadays, there is a need for an increased emphasis on in-class active learning activities in the curricular delivery in Pharmacy (Pharm) schools in order to perform the European Higher Education Area’s (EEES) guidelines. Pharmacy programs employ diverse active teaching and learning strategies in the delivery of physiology contents to graduate of Pharm students. Active learning is the notion that students must read, write, discuss, and engage in problem solving to maximize their potential for intellectual growth [1]. Among other, flipping the classroom, team-based learning, simulation-based education, in-class discussion/recitation, projects, problem-based learning (PBL), or team-based learning are some strategies commonly employed as active learning methods in health studies [2].
The active learning methodologies have been reported to improve students’ learning outcomes compared with conventional physiology lecture \[3, 4\]. Studying Physiology requires selecting or creating teaching strategies that help students to learn, thus being indispensable for the teacher to become a mediator of the process of knowledge construction, stimulating participation and understanding the uniqueness of those involved in the process. Understanding Physiology also requires students to have the facts and the ability to utilize effective problem solving skills \[5\]. Thus, Human Physiology is an example of area knowledge that has been significantly transformed in higher education \[6\]. These changes aim mainly to develop professional profiles that include abilities beyond the well-established technical skills, to prepare students for the real world. Students need opportunities to see how experts analyze problems, get feedback on their actions, and get suggestions during the process. The active PBL methodology derives from the theory that learning is a process in which the learner actively constructs knowledge, developing analytical and organization capacities, decisions, task planning and problem solutions \[5\]. The higher education can be more effective if teaching takes place in the context of real-world problems or professional practice \[7, 8\]. The integration of science and practice curricula within pharmacy is crucial in generating graduates capable of applying basic science principles to solve therapeutic problems \[9\]. In PBL, students are put in an active learning environment by giving them problems and training them to identify what they need to learn to solve those problems \[5\]. Previously, we have demonstrated that the use of PBL strategy during didactic lectures and practical session improves students’ ability to learn physiology \[10, 11\] and physiopathology \[12, 13, 14\]. The introduction of case-scenarios for classroom discussion/case-based learning would be more effective at helping them to learn physiological concepts compared with more traditional laboratory learning. The integration of various active learning activities allows the students to improve the students’ skills and gain a detailed understanding of the processes involved in how the body works in health and in disease \[7\]. In a recent study, we have described the development and the implementation of a novel trilayer innovative teaching method to teach digestive physiology in the Pharm degree of UCM \[10\]. This recent experience provided students with the opportunity to gain a first-hand laboratory experience of the structure, function, and development of the digestive system \[10\]. We encourage learning of digestive system physiology developing a range of practical competencies based in the area of laboratory skills by using several active conventional teaching methods. Computer based learning (CBL) facilitated the resolution of case in the laboratory teaching practice in physiology programs \[10,15\]. The PhysioEX 9.0 software allowed students to use a simulation virtual laboratory \[16\]. Virtual laboratory exercises and tools enabled students to learn at their own pace, revisit exercises, and at a time and location to suit themselves \[15\]. Through the histological study of the structures of the digestive system, students learn to integrate human anatomy and physiology and consolidate basic knowledge \[10,17\]. Some of these teaching styles employed were previously done independently of each other. In this study, we evaluated the efficiency of the implementation of PBL combined with active conventional learning method. The two main objectives proposed in this study were to assess student perception of PBL as a teaching methodology implemented in a conventional practical class setting and to measure improvements in problem-solving skills due to the inclusion of clinical case using PBL in addition to standard practical strategies.

2 METHODOLOGY

PBL was introduced in the Physiology course taught to second-year undergraduate during the second semester of the Pharm curriculum. The Physiology practical module consists of 10 practical sessions with a total of 25 hours long (1 ECTS credit) which are imparting during 3 hours every day along 2 weeks. The present pilot experience has been carried out in practical groups of 30-36 students divided into smaller groups of 2-4 students. In this study, PBL was introduced to mixed-methods approach to traditional practical lectures session. In order to evaluate the efficiency of the implementation of PBL, we obtained two experimental groups: one group including problem-based learning (PBL) to conventional teaching and another one without PBL (Non-PBL). We compared both groups to know the degree of satisfaction and academic achievement of the students.

2.1 Teaching methods and preparation of materials

The study of digestive system was the chosen practice for including of PBL method. A related to a real physiological situation problem about digestive system was prepared by lectures and presented to the students in the UCM Virtual Campus. During the preparatory phase, implicated teachers were oriented about PBL methodology and the clinical case and tutor guides were prepared. The conventional
teaching method consisted in the implementation of physiological simulation and histological analysis [10]. The PhysioEX 9.0 computer program allowed to the students to use a virtual laboratory. PhysioEx™ 9.0 software consists of 12 exercises containing 66 physiology lab activities that allow complementing the theoretical and practical contents previously taught in Physiology [16]. Each 2-3 students shared a computer to carry out the practice collaboratively and discuss the results between them. The focus of this lab exercise was the chemical digestion, essential for breaking food into particles that can be absorbed by the epithelium of the small and large intestine. The chemical processes of digestion were studied by analyzing the different factors that influence into the activity of the hydrolytic enzymes of the gastrointestinal tract. Influence of the changes in the pH and temperature on the rates of enzyme-catalyzed reactions was emphasized. The activity of each enzyme on its substrate was measured, demonstrating the specificity of the enzymatic function for each substrate. The practice is completed with the histological study of the digestive system structures by using slices from histological sections of the stomach, small and large intestine, salivary glands, pancreas and liver. Students were introduced to advanced histology techniques to illustrate the physiological functions of organs and systems and their pathologies, providing a microscopy study of the tissues on which students can make observations while promoting their critical thinking skills [10]. Practice Guidelines for the students were designed with related questions for the development of the practice and the use of it was valued. Feedback from the learning was done through the development of a Teacher's Guide, in which indicate the specific learning objectives, the learning resources and the lines of necessary action to handle problems that may appear during the process of learning. The extensive teaching experience of the teachers involved is a guarantee for the achievement of the learning objectives set [10,12,13,14].

2.2 Implementation of PBL

Students were informed about PBL method in the inaugural theory class of Physiology. We utilized the existing infrastructure in our Department to design and implement a PBL module. Before the ‘laboratory’ session, a real case-problem about digestive physiology was considered. The students could access, through the UCM Virtual Campus, to the description of the practical case-problem and questionnaires with enough time for its completion by autolearning, searching bibliography on their own. Students were required to answer questions about the case by self-learning using themselves bibliography sources. Thus, before the practical session students ought to analyze a case-problem about digestive physiology, as a real physiological situation, formulated hypothesis, and undertook self-directed learning tasks (Practical Guidelines, physiology books, videos, PowerPoint slides, online resources, etc......). Students contributed to the resolution of the practice with the knowledge previously learned. Students were provided with clear guidelines for aims of the debate and related questions for the development of the practice session. During session, the group of students chose a moderator, who was in charge for controlling the time of the session, and ensuring the participation of the rest of the students and a "notary" who collected the contributions of the session, taking the notes of the session on the board. Students brought the answers to the questions about the case-problem resolving to debate and discussion. In addition, students consolidated and searched for the answers to the questions of the clinical case, by carrying out the virtual simulation and studying the histological sections of the digestive system under a microscope. This served as a feedback mechanism for the self-learning carried out by students. At all time, debate was established in small groups and the student who acts as "notary" takes note of the results. During the sessions, the case was discussed in details, ensuring the participation from every student by the facilitators. The teacher had a passive role, resolving doubts derived from debate and the discussion of the case. Students had an active role discussing aspects of digestive physiology and providing ideas, knowledge and also doubts about what the student knows and what is not understood on the subject.

2.3 Assessing problem-solving skill: Satisfactory survey

To know the assessment of the students after the practice, a voluntary questioner about inclusion of PBL teaching methodology was carried out. Responses about their pharmacy student competencies after finished experience were scored using a five-point Likert scale, where 0 = strongly disagree, 1 = disagree, 2= neither agree nor disagree, 3= agree, and 4= strongly agree. These competencies were evaluated in a survey composed by 10 questions to evaluate the efficiency of PBL implementation in a combined teaching and learning strategy for physiology practical lesson. The final questionnaire was composed of the following ten questions: Question 1. Did PBL increase my motivation to participate in class? Question 2. Did PBL help to understand the concepts covered in the clinical case? Question 3. Did PBL help to refine my creative and critical thinking skills? Question 4. Did PBL promote...
2.4 Assessing knowledge enhancement: pre and post-test

The assessment of the acquired knowledge from the clinical case consisted of both pretest and posttest which were adopted as an additional measuring tool. A pretest/posttest developed by the teacher was administered to the students to evaluate the knowledge enhancement base on PBL. These consisted of a 10-items examination in relation to digestive clinical case. The pre-test was distributed before practical session and the post-test was administered at the end of the practical class along with the student satisfaction assessment course survey. This test needed each participant to have both pre- and post-test scores. Due to this, some students (n=2) were dropped from the analysis because they had only one score.

2.5 Data Analysis

SPSS software (version 25.0, SPSS, Chicago, IL) and Graphpad Prim 6.0 were used to conduct the statistical analyses and graphics of the data. Individual student answers to the same questions showing the student perception survey data respect to PBL and conventional teaching styles were collected, and differences in student answers assessed by the nonparametric paired sample sign test. In the case of the problem-solving exercises, experiments were designed to allow pairwise comparisons between the score of pre- and post-PBL of individual students by a Student’s t-test for paired observations. P values less than 0.05 were considered to be statistically significant. Reliability was described as the internal consistency of the dimensions and determined using the Cronbach’s alpha coefficient. The expected alpha coefficient was estimated at 0.75. [18,19].

3 RESULTS

3.1 Analysis of Student Survey

Anonymous post practical session questionnaires were completed by students of both groups to elicit survey rankings. Student feedback about the inclusion of PBL strategy was very positive. Table 1 represents the means of the degree of satisfaction of the students calculated from the survey (non-PBL n=36; PBL n= 28). Ten questions on the impact of the combination of the PBL methodology with conventional teaching methods applied in the digestive physiology study were analysed in the survey. Cronbach’s alpha reliability coefficient were 0.825 (PBL) and 0.929 (not PBL), respectively indicating a very good reliability of the rating scale.

There was a statistically significant difference between the two groups regarding their overall satisfaction with the implementation of PBL. The analysis of surveys showed good agreement on the response to the most of the questions. The students satisfaction survey found that all of questions were scored range from agree level of mean score and most of modes were about 2.5 (agree). There was strong agreement that the educational outcome of PBL was better than conventional practical sessions. The Q4 (PBL=3.03, agreed), Q7 (PBL=3.54, strongly agreed) and Q9 (PBL=3.03, agreed) questions were the best valued showing the highest scores which indicates that the students understood the concepts and the clinical meaning of the practice better by valuing very positively the discussion and the debate (Q4=36.58%, P=0.004; Non-PBL vs PBL), increasing the interest and involvement of students working in groups and encouraging participation among work teams (Q7=42.90%, P=0.000; Non-PBL vs PBL) and emphasizing the importance of PBL for their professional future as a future pharmacist (Q9=26%, P=0.006; Non-PBL vs PBL). The highest differences between the non-PBL and PBL groups were observed in Q1 (Q1=73.45%, P=0.000; Non-PBL vs PBL) indicating that PBL implementation improves student motivation to participate in class despite the low opinion scores recorded in this item (Non-PBL=1.07 (disagree) vs PBL= 2.48 (agree)). Students agreed/strongly agreed that the educational outcome of PBL was better than conventional practical sessions. The Q4 (PBL=3.03, agreed), Q7 (PBL=3.54, strongly agreed) and Q9 (PBL=3.03, agreed) questions were the best valued showing the highest scores which indicates that the students understood the concepts and the clinical meaning of the practice better by valuing very positively the discussion and the debate (Q4=36.58%, P=0.004; Non-PBL vs PBL), increasing the interest and involvement of students working in groups and encouraging participation among work teams (Q7=42.90%, P=0.000; Non-PBL vs PBL) and emphasizing the importance of PBL for their professional future as a future pharmacist (Q9=26%, P=0.006; Non-PBL vs PBL). 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Q10, the overall opinion of the PBL strategy (Non-PBL= 2.09 (disagree) vs PBL= 2.74) (agree)) showed a higher level of satisfaction than non-PBL (Q10- 31.43%, P= 0.011; Non-PBL vs PBL). In summary, Q4, Q7 and Q9 questions were the best valued which indicates that the students understood the concepts and the clinical meaning of the practice better, valuing very positively the discussion and the debate, involving students to work in groups and encouraging participation among work teams and emphasizing the importance of PBL for their future as pharmacist. The promotion of self-learning (Q5) was the least valued issue.

Table 1: Student's satisfaction to the implementation of PBL to the conventional practical teaching calculated from the surveys.

<table>
<thead>
<tr>
<th>Items</th>
<th>non-PBL</th>
<th>PBL</th>
<th>P</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1. Increased my motivation to participate in class</td>
<td>1.57 ± 0.23</td>
<td>2.71 ± 0.16</td>
<td>0.000</td>
<td>73.41</td>
</tr>
<tr>
<td>Question 2. Helped to understand the concepts covered in the clinical case.</td>
<td>2.13 ± 0.16</td>
<td>2.80 ± 0.12</td>
<td>0.001</td>
<td>31.43</td>
</tr>
<tr>
<td>Question 3. Helped to refine my creative and critical thinking skills.</td>
<td>1.96 ± 0.19</td>
<td>2.86 ± 0.11</td>
<td>0.000</td>
<td>46.03</td>
</tr>
<tr>
<td>Question 4. Promoted discussion.</td>
<td>2.22 ± 0.18</td>
<td>3.03 ± 0.19</td>
<td>0.004</td>
<td>36.58</td>
</tr>
<tr>
<td>Question 5. Promoted my self-learning.</td>
<td>2.22 ± 0.19</td>
<td>2.57 ± 0.15</td>
<td>0.153</td>
<td>15.97</td>
</tr>
<tr>
<td>Question 6. Encouraged my ability to seek information.</td>
<td>2.00 ± 0.20</td>
<td>2.66 ± 0.13</td>
<td>0.005</td>
<td>32.86</td>
</tr>
<tr>
<td>Question 7. Increased my comfort level in working in groups.</td>
<td>2.48 ± 0.22</td>
<td>3.54 ± 0.09</td>
<td>0.000</td>
<td>42.96</td>
</tr>
<tr>
<td>Question 8. Enabled to synthesize complex, but clinically meaningful information.</td>
<td>2.09 ± 0.17</td>
<td>2.86 ± 0.12</td>
<td>0.000</td>
<td>36.90</td>
</tr>
<tr>
<td>Question 9. It was useful for my success as a future pharmacist.</td>
<td>2.39 ± 0.20</td>
<td>3.03 ± 0.13</td>
<td>0.006</td>
<td>26.65</td>
</tr>
<tr>
<td>Question 10. My level of satisfaction is .....</td>
<td>2.09 ± 0.23</td>
<td>2.74 ± 0.14</td>
<td>0.011</td>
<td>31.43</td>
</tr>
</tbody>
</table>

Non-PBL group: conventional learning without including problem-based learning (n=36). PBL group: combination of conventional learning and the implementation of PBL (n=28). Values are mean and SEM of score in response to the survey questions. Responses were scored using a five-point Likert scale, where 0 = strongly disagree, 1= disagree, 2 = neither agree or disagree, 3 =agree, and 4 =strongly agree. Statistical significant differences P<0.05 by a Student’s t-test for paired observations. Also the percentage of satisfaction score increase was showed (%).

3.2 Problem-Solving Exercise: Analysis of pre and post-test

Pre-test and post-test practical session questionnaires were completed by students of both groups to elicit survey rankings (Figure 1). The results showed that students had scored considerably higher on the problem solving skills post-test than on the pre-test. For the PBL pre-test, the mean score was 7.19, with a standard deviation of 1.60 and a range of 2.5 to 10, while for the PBL post-test, the mean score was 8.11, with a standard deviation of 1.42 and a range of 5 to 10. The average rating significantly increased by 19.8%, P= 0.0055 (Paired t-test). The number of students who obtained the highest score (score=10) in the post-test (n=10) was much higher than in the pre-test (n=2), showing the effectiveness of PBL strategy.

![Figure 1: Scores from pre-test and post-test from PBL students](image)
4 CONCLUSIONS

Teachers in our Department of Physiology have been challenged to propose active teaching-learning methods that allow the development of students’ competencies. Active learning helps to create new possible settings of professional training in superior education. In the present report, we demonstrate that PBL implementation in addition to both the use of real physiology simulations and the histologic study of structures of digestive system enhances positively the outcomes on student opinion and the competences acquired with the learning process. Data from student satisfaction survey and question scores showed that students achieved the subject-specific skills development and new subject knowledge. PBL implementation significantly increased the ability of students to develop transversal competences related to working in teams such as critical thinking or problem solving or communication. Also the interaction between the designed materials for learning promoted improvements in creative thinking, acquisition of critical assessment and management skills which leading to synthesize and to understand complex information. Beside, this study proves that the students were very motivated to understand the concepts clinical posed. Establishment of PBL strategy in clinical scenarios might help students discuss and explain the physiological process in a professional context. Although the results of the survey do not suggest that PBL helped to the students to take a higher responsibility for their own learning (a main EEES’ transversal competence), we found that students could construct the information in their minds and comprehend the subject better by actively searching the information themselves to resolve the posed problem. In this sense, the intervention by instructors should be kept under consideration to improve self-directed learning PBL-induced. The integrated histologic learning conducted in this study could be able to guide students to conclude the findings about the clinical case from data collection process from the simulation experiment and histological diagnosis that they have carried out. Also, students performed their own learning feedback. Students’ became aware of their mistakes especially in areas of communication and knowledge sharing, and so learnt not to repeat the mistake in the future. In relation to academic competences, the scores of pre-test and post-test showed significantly different in PBL students. The post-test attained higher scores on the problem solving skills respect to the pre-test, demonstrating greater knowledge acquisition. As the results of our study, the PBL groups showed a more positive learning attitude and higher motivation in comparison with the control group who were subjected to traditional-based method of learning. Students learned to correlate relevant enzymatic mechanisms, histological, and clinical features with the clinical signs and symptoms, to learn the digestive physiology. These results suggest that the combined implementation of PBL could be used as an alternative method in teaching Pharm students because it is more effective and motivates the students. We believe that combined PBL strategy could be used in a practical classroom setting to instruct subject related to the biomedical field including pharmacology, physiology, and biochemistry and/or also in similar courses in other professional programs. Overall concluded that the combined PBL strategy enhances Pharm student competencies and students were satisfied with the new mixed PBL methodology.

REFERENCES


Problem-based learning (PBL) is a student-centered approach in which students learn about a subject by working in groups to solve an open-ended problem. This problem is what drives the motivation and the learning. Why Use Problem-Based Learning? Nilson (2010) lists the following learning outcomes that are associated with PBL. A well-designed PBL project provides students with the opportunity to develop skills related to: Working in teams. Instead of short-term memorization strategies, project-based learning provides an opportunity for students to engage deeply with the target content, bringing about a focus on long-term retention. PBL also improves student attitudes toward education, thanks to its ability to keep students engaged. These interpersonal aspects of PBL dovetail perfectly with the use of technology in the classroom. Technology-based projects are interdisciplinary, collaborative, inquiry-based, self-directed, motivating, and address the full range of student needs and learning styles, according to Christa Love of TechnoKids. Teacher Magazine’s Effective Implementation of Project-Based Learning. See this article >>. Twenty-first century skills necessitate the implementation of instruction that allows students to apply course content, take ownership of their learning, use technology meaningfully, and collaborate. Problem-Based Learning (PBL) is one pedagogical approach that might fit in your teaching toolbox. PBL is a student-centered, inquiry-based instructional model in which learners engage with an authentic, ill-structured problem that requires further research (Jonassen & Hung, 2008). Students identify gaps in their knowledge, conduct research, and apply their learning to develop solutions and pre In implementing PBL, the teaching role shifts from that of the more traditional model that follows a linear, sequential pattern where the teacher presents relevant material, informs the class what needs to be done, and provides details and information for students to apply their knowledge to a given problem. With PBL, the teacher acts as a facilitator; the learning is student-driven with the aim of solving the given problem (note: the problem is established at the onset of learning opposed to being presented last in the traditional model). Usually, in PBL, each group presents their solutions via a team presentation either to the class of other students or to those who are related to the problem. Both the process and the results of the learning activity need to be covered.