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**IMPACTO DE LA IMPLEMENTACIÓN DEL APRENDIZAJE
BASADO EN PROBLEMAS EN COMBINACIÓN CON LAS
PRÁCTICAS DE LABORATORIO CLÍNICO Y VIRTUAL DE
FISIOPATOLOGÍA PARA EL DESARROLLO DE
COMPETENCIAS PROFESIONALES**

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1. Objetivos propuestos en la presentación del proyecto

El objetivo general del presente Proyecto ha sido la puesta a punto y evaluación de la implementación del aprendizaje ABP como una nueva metodología mixta integrada en la docencia práctica de la asignatura de Fisiopatología del Grado en Farmacia de la UCM.

Se persiguen los siguientes objetivos concretos:

. Diseño, adaptación y puesta a punto de la metodología ABP mejorando el entorno de aprendizaje con el fin de incrementar el interés y motivación del alumno por la materia al involucrarle directamente en el proceso.

. Conseguir que los alumnos adquieran las nuevas competencias de aprendizaje que dictan las directrices de la EEES, como son la implicación en su propio aprendizaje, el desarrollo de un autoaprendizaje duradero, la generación un pensamiento crítico y la discusión en grupos de trabajo que favorezca la participación y el intercambio de información.

. Intentar que el alumno adquiera las destrezas derivadas de la práctica en el laboratorio, la simulación fisiopatológica y la evaluación crítica de ensayos preclínicos y clínicos, que les conduzca a la resolución del caso-clínico propuesto, lo que les será útil para su futuro profesional.

. Valorar y medir la eficacia del método integrado mediante la evaluación del conocimiento y de las competencias y destreza adquiridas.

Objetivos curriculares y competencias

El contexto teórico del presente Proyecto se corresponden con el tema 26 del programa de Fisiopatología del Grado de Farmacia de la UCM: "Alteraciones endocrinas de las gónadas masculinas y femeninas. Hiper e hipogonadismo masculino. Hiperestrogenismo e insuficiencia ovárica".

Se estudian los siguientes objetivos curriculares:

- Identificación de las fases del ciclo ovárico. El alumno podrá conocer y comprender la estructura y función ovárica y sus alteraciones.

- Evaluación y diagnóstico citológico vaginal de pacientes con identificación de casos de disfunción ovárica. El alumno podrá conocer los mecanismos generales de la enfermedad, alteraciones moleculares, estructurales y funcionales del exocérvix e interpretar análisis biológicos y su relación con la disfunción ovárica.

- Estudio de los efectos la administración de estrógenos o calcitonina como terapia sustitutiva hormonal a unas ratas ovariectomizadas. El alumno será capaz de evaluar los efectos terapéuticos hormonales y sus consecuencias sobre la salud y enfermedad y su aplicación farmacológica.

Por otra parte, la implementación del ABP contribuirá al desarrollo de las siguientes competencias definidas en el Grado de Farmacia:

Competencias básicas y generales

- Comprender y aplicar los conocimientos en el ámbito profesional.
- Reunir e interpretar los datos relevantes para emitir juicios científicos.
- Transmitir información, ideas, problemas y soluciones al problema y cuestiones planteadas.

Competencias transversales

- Compromiso ético-profesional.
- Capacidad de aprendizaje y responsabilidad. Autoaprendizaje.
- Consolidar conocimientos de otras materias afines que son básicas para el aprendizaje de la Fisiopatología.

Competencias específicas

- Diseñar, aplicar y evaluar reactivos, métodos y técnicas analíticas clínicas
- Evaluar pruebas y análisis de diagnóstico.
- Capacidad para prestar consejo terapéutico en farmacoterapia y evaluar los efectos terapéuticos hormonales.
- Intervenir en las actividades de promoción de la salud y prevención de la enfermedad.

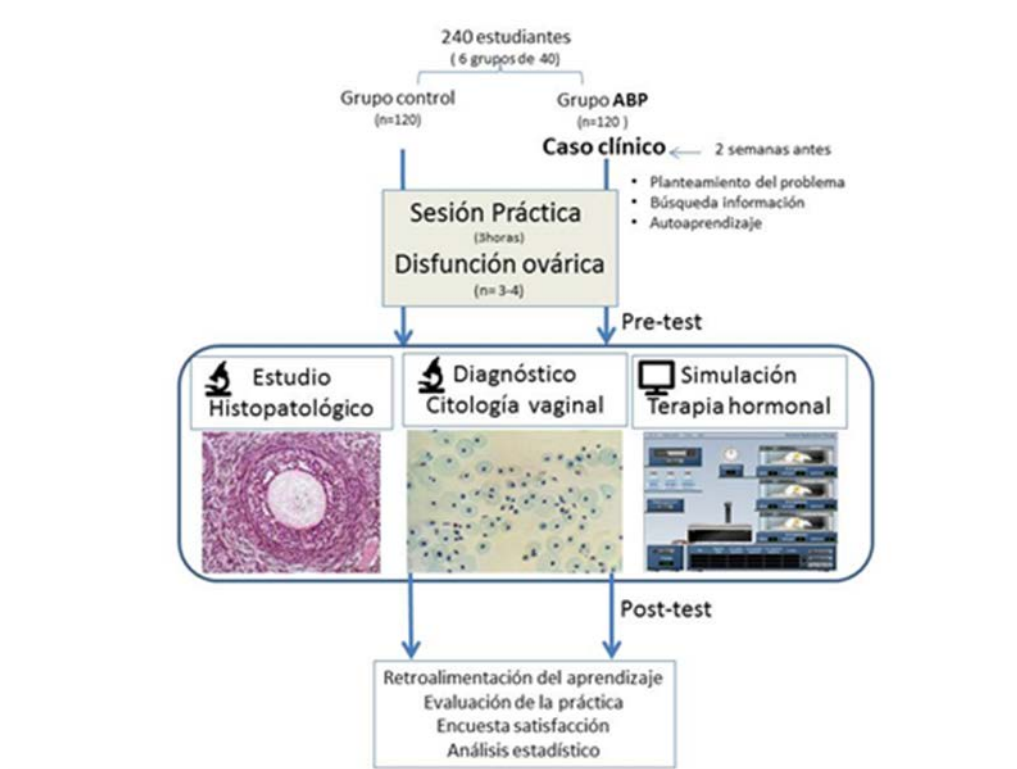


Figura 1: Esquema del diseño y evaluación de una nueva herramienta mixta que se incorpora el ABP a otras metodologías tradicionales, como prácticas de laboratorio innovadoras y simulaciones en ordenador en la práctica de Fisiopatología del sistema reproductor femenino.

2. Objetivos alcanzados

Todos los objetivos propuestos en este Proyecto se han alcanzado de manera muy satisfactoria y se han conseguido en su totalidad. Los resultados se han enviado a tres Congresos Internacionales especializados en innovación docente y han sido publicados en los Proceedings. Previamente a la realización del Proyecto, se elaboraron los siguientes materiales docentes que han sido utilizados para implementar el método docente o para medir el impacto de la inclusión del ABP en la práctica de fisiopatología del aparato reproductor femenino:

- Guía de la práctica donde se explica la metodología y se dan instrucciones.
- Guía histológica y citológica con las estructuras que deberán caracterizar y diagnosticar.
- Guía de la simulación PhysioEX 9.0.
- Presentación Power Point con esquemas y breve descripción de los conceptos.
- Enlaces a sitios Web como recursos bibliográficos y otras fuentes.
- Cuestionario de comprensión y resultados de la práctica para trabajar en el aula y en grupo para cada uno de los apartados.
- Guía del Profesor que permite la retroalimentación del aprendizaje donde se indican los objetivos específicos, los recursos pedagógicos y las líneas de actuación necesarias para el manejo de problemas que pudieran aparecer durante el proceso de aprendizaje.
- Cuestionarios pre- y post-test para la valoración de los conocimientos aprendidos antes y después de la práctica.
- Estadillo de la encuesta de satisfacción de los alumnos donde se valora la metodología aplicada y el aprendizaje.

La experiencia y los resultados obtenidos en este Proyecto nos permite concluir, que la utilización de estrategias pedagógicas mixtas, en las que se incorpora el ABP a otras metodologías tradicionales, como prácticas de laboratorio innovadoras y simulaciones en ordenador, junto con el uso del Campus Virtual, ayudan a obtener mejores resultados en los procesos de enseñanza y aprendizaje. Los resultados obtenidos han sido presentados en Congresos de innovación docente y publicados en revistas especializadas. Los resultados relativos al diseño, objetivos y expectativas de esta nueva metodología mixta se han publicado en ICERI2019 Proceedings ISBN: 978-84-09-14755-7 y se muestran en la Publicación 1 del Anexo de esta Memoria. El cumplimiento de los objetivos curriculares se valoraron a través de los resultados de los exámenes finales realizados por los alumnos, que han sido publicados en INTED2020 Proceedings ISBN: 978-84-09-17939-8 (Anexo: publicación 2) y de los resultados del pre y post-test, publicados en EDULEARN2020 Proceedings ISBN: en prensa, (Anexo: publicación 3). Los resultados obtenidos de las encuestas de satisfacción de los estudiantes se presentarán en el próximo Congreso ICERI20 “13th annual International Conference of Education, Research and Innovation” que tendrá lugar en noviembre de 2020, estos resultados están pendientes de su publicación.

Así mismo, se concepcionaron las siguientes guías de la práctica que se encuentran a disposición de los alumnos en el Campus Virtual y están pendientes de mandar a publicar a la editorial Complutense.

- Guía de la práctica donde se explica la metodología y se dan instrucciones.
- Guía histológica y citológica con las estructuras que deberán caracterizar y diagnosticar.
- Guía de la simulación PhysioEX 9.0.
- Presentación Power Point con esquemas y descripción pormenorizada de los conceptos y objetivos del aprendizaje.

El uso del modelo de enseñanza integrado con ABP condujo a una mejora significativa en el rendimiento de los estudiantes. Se realizaron exámenes estandarizados de preguntas de opción múltiple, sobre casos de pacientes relacionados con el diagnóstico histopatológico, citología del cuello uterino y la terapia de reemplazo hormonal, respectivamente. Los resultados de las pruebas mostraron que los estudiantes pudieron analizar y explicar los efectos de la disfunción ovárica, estudiar las diversas variables que la afectan, definir los riesgos de la progresión y el desarrollo de esta enfermedad, criticar las pruebas de diagnóstico y determinar su relación con los signos y síntomas. Los estudiantes contestaron mejor a las preguntas que requerían que la información fuera analizada y/o aplicada clínicamente. Además, el rendimiento del grupo de estudiantes de ABP en el post-test fue significativamente superior al del pre-test, confirmando la mejora en la adquisición de conocimiento. También, el análisis de las encuestas de satisfacción de los estudiantes mostró un fuerte acuerdo en que la inclusión del método ABP fue mejor que las sesiones prácticas convencionales (datos pendientes de publicar).

Por otra parte, además del incremento del rendimiento académico de los estudiantes, también mejoró su pensamiento crítico para comprender los principios fisiopatológicos de la disfunción ovárica. Muy probablemente, el hecho de que el alumno tenga que recopilar resultados e interpretarlos, contribuya a consolidar el conocimiento a través del razonamiento y el pensamiento crítico, que conducen a resolver el caso clínico planteado. El uso de casos clínicos de la vida real y su resolución mediante el diagnóstico de citología vaginal y la simulación de la terapia de reemplazo hormonal demostraron ser muy efectivos y facilitaron las habilidades prácticas potenciales de los estudiantes. A su vez este método mixto podría llevarse a cabo para revelar mayor percepción de los estudiantes sobre la experiencia basada en problemas. También, esta nueva herramienta mixta motivó a los alumnos a implicarse y discutir con sus compañeros. La inclusión de ABP también permitió una mejor definición del problema y la formulación de los objetivos del aprendizaje, fomentó la búsqueda de información fuera del grupo, favoreciendo el autoaprendizaje, y promovió la participación en grupo para ordenar las ideas, sistematizar y profundizar en los conceptos, verificar nuevas ideas y esclarecer las dudas analizando el problema.

Podemos concluir que este método de enseñanza innovador mejoró la capacidad del estudiante para integrar información de diferentes temas de aprendizaje tradicionales y para aplicar dicho contenido de conocimiento integrado al resolver problemas clínicos.

La inclusión del aprendizaje básico de problemas con las prácticas de laboratorio de fisiopatología en los planes de estudio de Farmacia, podría ser una mejor estrategia de enseñanza que garantice la competencia de los graduados en pensamiento crítico y resolución de problemas. Además, la nueva estrategia de enseñanza integradora se centra en el aprendizaje de los estudiantes sobre cómo usar el conocimiento científico para resolver preguntas clave de fisiopatología con una proyección profesional, y puede ser una estrategia educativa útil en la enseñanza y el aprendizaje de los farmacéuticos a nivel universitario, por lo que podría ser adoptado por instructores en cursos similares en otros cursos y grados profesionales.

3. Metodología empleada en el proyecto

La metodología mixta ABP aplicada en este Proyecto ha sido implantada siguiendo los siguientes pasos:

1. Presentación en el Campus Virtual del tema, los objetivos, la motivación y la creación de expectativas e interés por el tema. Autoaprendizaje del estudiante a partir búsquedas de fuentes propias. Intento de resolución del caso clínico.
2. Identificación de las ideas previas. El estudiante toma conciencia de sus conocimientos. Distribución en grupos y realización del pre-test.
3. Se cuestionan las ideas previas que han adquirido los estudiantes por autoaprendizaje, se introducen los nuevos conceptos para comparar ideas previas con las teorías científicas adquiridas y toma de conciencia. Resolución del caso clínico con ayuda de la recogida de datos de las prácticas de laboratorio, diagnóstico histopatológico, citología vaginal y simulación por ordenador. Adaptación a la base de conocimientos.
4. Se afianzan los conocimientos adquiridos, se motiva a los estudiantes para profundizar en nuevos conocimientos y se comprueba la funcionalidad y aplicabilidad del aprendizaje logrado.
5. Se comprueban los objetivos logrados y se afianzan y refuerzan los aprendizajes alcanzados. Se motiva a los estudiantes para que realicen procesos de metacognición. Se realizan pruebas post-test y encuestas de satisfacción. Se realiza examen final de prácticas y se extraer los resultados de las preguntas relativas a la práctica de Fisiopatología del sistema reproductor.
6. Se realiza el análisis estadístico de los datos recopilados para extraer resultados y conclusiones de la efectividad del método.

4. Recursos humanos

El profesorado de la Sección Departamental de Fisiología que forma parte de esta solicitud imparte la asignatura de Fisiopatológica en el Grado en Farmacia y que tiene una amplia experiencia en la impartición de ABP en las sesiones prácticas y seminarios de las asignaturas de la Sección. El grado de consecución de los objetivos alcanzados ha sido posible gracias al dominio que posee el profesorado de esta Sección Departamental en la materia impartida y a su capacidad creativa. La distribución y ejecución de las tareas en las distintas etapas del Proyecto y la buena coordinación entre el profesorado se han realizado de forma muy satisfactoria. También es preciso resaltar la capacidad de cohesión y de trabajo en grupo del profesorado que ha llevado a la consecución de muy buenos resultados. También destacamos la valiosa colaboración del personal de la Administración y Servicios de la Sección Departamental de Fisiología y de los Servicios Generales de la Facultad de Farmacia. Debido al carácter mixto de la metodología docente aplicada en este Proyecto, la función de los técnicos de laboratorio adscritos a nuestra Sección

Departamental ha permitido la organización y el mantenimiento del laboratorio para coordinar las estrategias docentes aplicadas. El PAS ha asistido al profesorado en la preparación de las aulas y los equipos informáticos necesarios para la simulación por ordenador, así como la organización del material necesario para realizar la práctica y desarrollar este Proyecto como son microscopios, muestras de histológicas y citológicas, entre otros... Debido al elevado número de estudiantes que han participado en este Proyecto, la labor de la secretaría administrativa en adjudicación de grupos de estudiados y en el manejo y confección de listados ha sido crucial.

5. Desarrollo de las actividades

La nueva metodología mixta con ABP fue presentada a los estudiantes en la clase inaugural de la docencia teórica de la asignatura de Fisiopatología en el mes de septiembre de 2019. Los alumnos participantes en el Proyecto fueron el conjunto de alumnos matriculados en la asignatura de "Fisiopatología" de tercer curso del grado en Farmacia, que se imparte en la Facultad de Farmacia de la UCM. La práctica elegida para este Proyecto fue "Fisiopatología del aparato reproductor femenino", en la que se estudiarán los mecanismos fisiopatológicos de la disfunción ovárica, y se corresponde con el tema 26 del programa teórico de Fisiopatología.

Para evaluar el impacto de esta nueva metodología mixta diseñamos una estrategia experimental en la que se comparan los resultados obtenidos en dos grupos de estudiantes: Grupo control (n=120), que recibió los contenidos de la práctica con metodología convencional basada en el laboratorio de prácticas, ensayos de diagnóstico clínico y en la simulación con el programa informático PhysioEX 9.0, y el Grupo experimental (ABP)(n=120), a los que, además de los métodos docentes tradicionales aplicados en el grupo control, se impartió la metodología mixta con inclusión de dos casos clínicos relacionados con la disfunción ovárica.

Durante la sesión de prácticas tradicional se valoran las fases del ciclo ovárico del ovario, utilizando cortes histológicos de conejo, teñidos con H&E a través de un estudio histológico en el microscopio óptico. Los alumnos identificaron las estructuras ováricas y las relacionaron con su función, así como con los mecanismos generales de la enfermedad, alteraciones moleculares, estructurales y funcionales, como se indica en la competencia CEM13. Además, los alumnos evaluaron y diagnosticaron la citología de frotis de fluido vaginal de pacientes, identificando los casos de disfunción ovárica mediante observaciones en el microscopio óptico según competencia CG3, y por último, el uso del programa informático PhysioEX 9.0 permitió a los alumnos utilizar un laboratorio virtual donde valoraron los efectos la administración de estrógenos o calcitonina como terapia sustitutiva hormonal a unas ratas ovariectomizadas, siguiendo una guía que les permitió hacer un seguimiento durante la simulación, según competencias CG15 y CT7 a CT22 publicadas en la ficha docente de la asignatura.

En la implementación de ABP se plantearon dos caso-problemas, derivados de una situación real fisiopatológica, previamente preparada por el profesor en base a los objetivos curriculares, educativos, de conocimiento, integración, capacidad crítica, etc... Los estudiantes pudieron acceder, a través del Campus Virtual, a la descripción de la lección práctica y a los cuestionarios de generación de hipótesis, con suficiente antelación para poder documentarse para su posterior cumplimentación. El día de la práctica, se realizaron las simulaciones fisiopatológicas y las observaciones microscópicas. En cada sesión, el grupo eligió un moderador -que se encargó de controlar el tiempo de la sesión y asegurar la participación de todos- y de un "notario" -que tiene registro el acta de lo que sucede en la clase. El profesor tuvo una función

relativamente pasiva, sirviendo exclusivamente de orientador de la marcha de la sesión para que ésta no se desvíe excesivamente de los objetivos educativos planteados para cada caso-problema. Su función fue garantizar que el grupo aborde el problema de una forma metódica, favoreciendo la interacción y las preguntas entre los miembros del grupo, con el fin de estimular el pensamiento crítico científico y un aprendizaje profundo y duradero de los conceptos a tratar. El orden de la sesión se diseñó de la siguiente manera:

1º Lectura del caso-problema e identificación de las ideas clave del texto relacionado con la fisiopatología del sistema reproductor femenino y con la realización de la práctica en concreto y obtención de resultados para responder al caso clínico (10-15 minutos).

2º Discusión de ideas durante la cual se debatió sobre los aspectos de la Práctica aportando ideas, conocimientos y también dudas sobre lo que el alumno conoce o duda sobre el tema (45-60 minutos).

3º Planteamiento de preguntas y consolidación del conocimiento (10-15 minutos).

Al final del periodo de docencia práctica y, una vez llevado a cabo el examen de la misma, se realizó un estudio comparativo entre los resultados de la calificación global del examen de prácticas en relación con las respuestas obtenidas en las preguntas de la práctica de fisiopatología del aparato reproductor femenino, de los estudiantes que participaron en la metodología ABP y de aquellos que recibieron una formación tradicional. La comparación de la efectividad del método mixto de ABP con respecto al rendimiento de los estudiantes se realizó utilizando la prueba *t* independiente y se consideró estadísticamente significativo un valor de *P* de ≤ 0.05 . Además, los experimentos se diseñaron para comparar por pares entre las calificaciones de pre-test y pos-test (*t*-student $P \leq 0.05$). Debido a que el pre-test y el pos-test contienen identificadores de los estudiantes, el uso de un ANOVA de medidas repetidas se incluyó en la comparación de los resultados, que sirvió para demostrar la mejora de conocimiento durante la sesión de la práctica. La correlación de Pearson entre pre-test y el post-test también se calculó para demostrar la estabilidad de los puntajes de los test de los estudiantes entre dos mediciones a lo largo del tiempo.

Además, la evaluación de la metodología se realizó al final de la docencia práctica de cada grupo de estudiantes, mediante encuestas sobre la idoneidad de cada uno de los diferentes materiales utilizados, así como de las actitudes generadas por la implementación del sistema ABP en la enseñanza la práctica. Se utilizaron encuestas de satisfacción de los estudiantes con 30 variables numéricas que se clasificaron por competencias transversales, curriculares, metodologías y sobre la actuación del profesor y se valoraron según la escala de Likert en 5 niveles teniendo en cuenta cinco puntos; del 1 al 5, siendo 1 "totalmente en desacuerdo" y 5 "totalmente de acuerdo" como puede verse en la publicación 1 el anexo. El coeficiente de Cronbach se utilizó como indicador de la homogeneidad de los ítems y de la consistencia interna de las encuestas. Entre otros se valoraron los siguientes conceptos: el grado de motivación que tienen los alumnos asistiendo a las prácticas, la motivación de los alumnos en la aplicación de nuevas tecnologías docentes, la motivación de los alumnos respecto al proyecto de ABP, la utilidad percibida de la realización de proyectos, si los alumnos prefieren realizar trabajos de manera grupal o individual, cuál de las herramientas utilizadas en la práctica les pareció más útil, así como la valoración global del método e intervención del profesor. También se valoró la integración de conocimientos básicos de la lección práctica, el desarrollo de pensamiento crítico científico, la potenciación de habilidades de comunicación y de defensa pública y el aprendizaje autónomo, perdurable y cooperativo. Los datos obtenidos de las encuestas, fueron recogidos en una hoja Excel para realizar un estudio preliminar de los resultados, posteriormente se

realizó un estudio estadístico utilizando para ello el programa SPSS vs 25.1. Además, los resultados de dichas encuestas fueron analizados y discutidos con los alumnos.

6. Anexos

PUBLICACIÓN 1:

M. Muñoz-Picos, C. Contreras, M. Hernández-Martín, C. Rodríguez-Prados, A. Sánchez, A. Agis-Torres, B. Climent, P. Recio, R. Raposo, S. Benedito, A. García-Sacristán, L. Rivera, D. Prieto, M. Hernández, M.E. López-Oliva

Designing practical PBL lessons for female reproductive system physiopathology teaching.

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DESIGNING PRACTICAL PBL LESSONS FOR FEMALE REPRODUCTIVE SYSTEM PHYSIOPATHOLOGY TEACHING

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Abstract

The link between theoretical and practical curriculum in Pharmacy degree is crucial in generating graduates capable of applying basic science principles to solve therapeutic problems. The use of traditional teaching strategies such as formal lectures or laboratory exercises allows students to consolidate theoretical knowledge. The European Higher Education Area guidelines point out to develop the critical capacity, self-learning, and approach the student to the professional reality, fundamental skills. Problem-based learning (PBL) is an excellent tool for the development of analytical and organization capacities, decisions, task planning and problems. In pharmaceutical sciences, use of PBL methods has been reported to be adequate to higher-level classes, such as Physiopathology. The basis of PBL lies in the authenticity or real-life application of the learning. The real problem stimulates students' interest and motivation to expand both major knowledge and skills. The inclusion of case-scenarios for classroom discussion or laboratory sessions seems to be more effective at helping student to learn pathological concepts compared with more traditional laboratory learning. In addition, computer based learning facilitates the resolution of case in the

laboratory teaching practice and enable students to learn at their own pace, revisit exercises, and at a time and location to suit themselves. For all this, we propose the design of a novel integrated mixed methodology by combination of the PBL with the laboratory practices and the virtual simulation. The progressive resolution of a clinical case related to the ovarian dysfunction in a simulated environment by performing clinical diagnosis from patients' biological samples will be the basis of learning. So, students will be able to solve the problem posed through the following curricular objectives: 1) Identification of the phases of the ovarian cycle by histopathological analysis with optic microscopy, students will be able to know and understand the ovarian structure, function and its alterations; 2) vaginal cytological diagnosis from patients with ovarian dysfunction posed in the problem case; 3) effects of the administration of estrogen or calcitonin as hormone replacement therapy to ovariectomized rats by using simulation PhysioEX 9.0 software, students will be able to evaluate the hormonal therapeutic effects and its consequences on health and disease and its pharmacological application. We will expect that this integrated pedagogic methodology allows to students to learn to solve professional reality problems linking theory with laboratory exercises; increasing content learning, skill development, and information collection; improving working with the equipment and analysing results; as well as enhancing critical thinking and students' overall understanding pathophysiological concepts. Fundamental to this method will be to expose students simultaneously to clinical and morphological data from posed case. The design of this novel teaching tool with an academic-professional profile will stimulate the capacity for integrated learning and the acquisition of fundamental transversal skills for the training of students of the degree in Pharmacy.

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Keywords: Problem based learning, Physiopathology simulation, Clinical diagnosis, Virtual campus, Integrated learning methodology.

INTRODUCTION

Physiopathology is a compulsory core subject of undergraduate pharmacy education. It is a modern integrative biomedical science that is concerned with the mechanisms responsible to the initiation, development, and treatment of pathological processes in humans and animals [1]. Traditional lectures, together with problem-solving activities in small groups, debates or practical computer classes are the main techniques to teach Physiopathology [2]. The European Union (EU) guidelines point out to develop innovative methods of teaching which aim to promote communication learning between teachers and learners and which take students seriously as active participants in their own learning, fostering transferable skills such as problem-solving, critical and reflective thinking and approach the student to the professional reality [3]. The efforts in enhancing the quality and relevance of learning and teaching in higher education should enable students to develop these transversal competencies that can best satisfy personal aspirations and societal needs, through effective learning activities. The Directive 2005/36/EC on the recognition of professional qualifications [4] regulates practical training for professionally oriented study programmes such as pharmaceutical studies. Through practical training students have the possibility of acquiring the skills demanded by employers. However, in our experience, although students manage to understand the underlying scientific principles, have a clear idea of the techniques used and acquire the skills necessary to perform the experiment, they are not able to link the contents of the practices to clinical problems that will be encountered as

pharmacists. Computer labs also are designed as a support and training tool. Computer based learning are designed as a support and training tool and facilitates students to understand and interpret physiopathology reality and enable them to learn at their own pace, revisit exercises, at a time and location to suit themselves [5]. Problem-based learning (PBL) is an excellent tool for the development of analytical and organization capacities, decisions, task planning and problems. The inclusion of PBL in Pharmacist curricula is considered one of the most efficient ways to enhance student learning, and it has been recognized as an effective way to prepare students for professional careers [6] The teaching staff of the Department of Physiology has extensive experience in teaching the Physiopathology subject by applying PBL strategies [7][8][9]. We have verified that the real problem stimulates students' interest and motivation to expand major skills, promoting critical thinking and clinical knowledge. However, if students are to think as pharmacists, alternative methods of teaching and examining must be considered. The inclusion of case-scenarios for classroom discussion to laboratory sessions could be more effective at helping student to learn pathological concepts compared with more traditional laboratory learning. The idea is that practical activities allow students to discuss pathological issues and their applicability to everyday and professional life and to exercise their capacity for critical analysis. Besides, students need to remember the previously learned knowledge of basic subjects such as anatomy, histology and/or physiology in order to understand complex pathological processes. To achieve this goal, in this study we propose to design an integrated teaching method that allows the interaction of several learning resources such as the study of clinical cases with student-led debates (PBL), virtual laboratories, and histological diagnostic practical classes for the study of female reproductive pathophysiology. In previous experience, the members of our Department of Physiology have incorporated PBL/small group learning in the laboratory session about physiology of the digestive system, and we demonstrated that combining PBL method with both virtual simulations and histologic study methods helped students to achieve meaningful learning with an effective and efficient teaching [10][11]. Here, we expect that this combined method let student practice their profession as pharmacists in the management of clinic issues related to endocrine female pathology.

METHODOLOGY

Learning context and Participants

Physiopathology is a required subject in the first semester of the third grade of Pharmacy curriculum. The Physiopathology practical module consists of 5 practical sessions with a total of 15 hours long (1 ECTS credit) which are imparting during 3 hours every day along a week. The present pilot experience will be carried out in groups of 30-36 students divided into smaller groups of 3-4 students. We will utilize the existing infrastructure in our Department to design and implement a new integrated learning strategy module.

Design and materials

Female reproductive system is the selected practical lesson to develop this project. Several related to real physiopathological case-problem situations about female reproduction system will prepare by lectures and presented to the students in the UCM Virtual Campus. In addition, students will have a significant experience with microscopic histopathology and cytosolic diagnostic as part of their pathology training. Regarding the diagnosis practical activities, first the students will receive instructions in a guide containing the aims and the materials and methods of each experiment so that they could then guide themselves through it. To perform the diagnosis, the students will be oriented to work by themselves alone or in small groups and afterwards to note their results and answer the discussion questions proposed by the professor in the guide. Practice Guidelines for the students will design with related questions for the

development of the practice and the use of it will be valued. Feedback from the learning will be 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 [7][8][9][10][11].

Implementation of PBL

Prior to the 'laboratory' session a case-problem about pathophysiology of female reproduction system will be considered, as a real physiological situation, previously prepared by the teacher. For that, students will access to the UCM Virtual Campus, to the description of the practical case-problem and questionnaires with enough time for its completion by self-learning by using bibliography on their own. In each session, the group of students will choose a moderator, who will be in charge to control the time of the session, and ensure the participation of the rest of the students and another student will be a "notary" who will collect all the contributions of the session, taking the notes of the session on the board. A debate will be established to solve the problem case questions. In addition, by carrying out the virtual simulation and studying the histological sections and the vaginal cytology under optical microscope will allow to students to answer to the questions of the clinical case. During the practical session, debate will be established in small groups and the student who acts as "notary" will take note of the results. Students will provide ideas, knowledge and also doubts about what they know and what is not understood on the subject. The case will be discussed in details, ensuring the participation from every student by the teachers as facilitators. The teacher will have a passive role, resolving doubts derived from debate and the discussion of the case.

RESULTS

Towards an improved clinic-oriented laboratory practical

This format is designed to allow for the use of histological diagnosis and computer simulations in a case-based context. The case-problem will be accompanied with basic questions, exposed on the Virtual Campus two weeks before session. The students are expected to find answers to the question, with learning resources provided in real-time in terms of internet access, articles and books, favoring the self-learning. Students will be divided into groups of 3 or 4. During 3 hour session, they will interact in an inquiry-based model to integrate self-generated laboratory data within clinical situations. The session will be divided into different activities (histological study and computer simulations) to diagnose patient samples related to the posed case, retaining student interest and attention. The group discussion focuses on creating an interactive environment between different groups and allows for exploration of alternative possibilities/answers to the questions posed. Curricular and transversal competencies will be achieved (Figure 1).

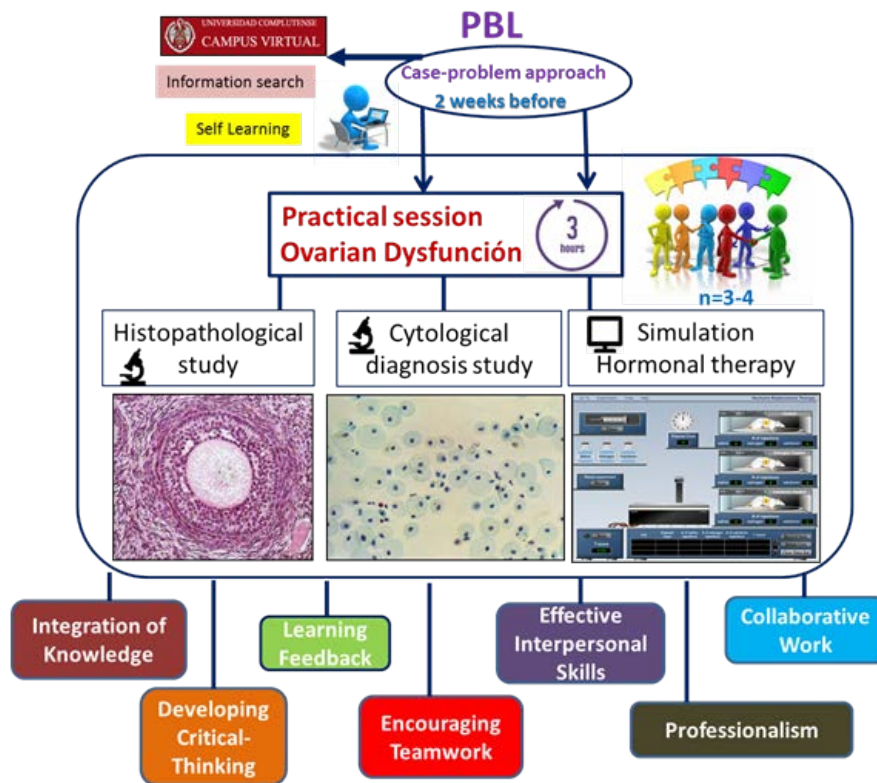


Figure 1: Schematic showing the design of the use of histological diagnosis and computer simulations in a case-based context as integrated PBL learning strategy

Curricular competencies

This practical session has been designed to allow students acquire an integrative and multidisciplinary knowledge about biomedical and clinical mechanisms of endocrine female physiopathology and their application in patient care. It has been demonstrate that practice-based learning improvements the ability to investigate and evaluate patient care practices, appraise and assimilate scientific evidence, and improve the practice of pharmacy [14]. Here, we focus specifically on the diagnostic process and the role of teams in achieving diagnostic accuracy. Health care professionals need improved education and training on the appropriate use of diagnostic tests and the application of these results to subsequent decision making in the disease treatment. To this end, students will perform optical microscope observations which allow them to perform histological and cytological diagnosis from animals or patients samples and use a computer simulation to resolve the posed clinic case-problem.

Optical Microscopy Examination

Histological Diagnosis: The histopathological records will carry out by students. By using of Hematoxylin and eosin (HE)-stained microscopic slides from ovarian specimens collected from experimental animals will be identified,

examined and diagnosed. Students will be 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. Student will study which slides illustrate the pathology posed in the case-problem and recognize the histological characteristics that help them to make the diagnosis or identify the ovarian dysfunction.

Uterine Cervix Cytology Diagnosis: The student will focus on the study of the menstrual cycle evaluating on dry-fixed and stained with metachromatic stains slide preparations from patient smears. An endocrine assay from each patient will be performed. Several types of cells will be observed from the smears and the menstrual phases will be defined for each patient. Tracking changes in the morphology of desquamated vaginal epithelial cells provides a convenient means of assaying changes in estrogen levels and complete the posed case-problem diagnosis. Interpretation of cervical cytology results will be reviewed by discussion groups. The relationship between stages of ovarian follicle maturation, phases of uterine endometrium, and cervical gland secretion will be discussed.

Simulated Computer Learning

Computer simulators are designed to model various aspects of human physiology, physiopathology or specific tasks or environments. Through PhysioEX 9.0 computer program, learners use information to make clinical decisions and observe the results in action. Simulated learning experiences get feedback during and after the interaction and expose students to clinical situations that they may never see in their practicum experiences. The PhysioEX 9.0 computer program allows the students to use a virtual laboratory [13]. Each 2-3 students shared a computer to carry out the practice collaboratively and discuss the results between them. The drop in estrogen levels associated with menopause and its replacement through hormone replacement therapy (HRT) potentially improving health will be studied by using of PhysioEx™ 9.0 software. The potentially linking HRT to osteoporosis, high risks of heart attack, stroke and other serious health problems will be reconsidered. Students will relate the results found in the computer simulation with the posed case-problem. By the simulation, student will resolve the clinical case questions and acquire concepts such as what is menopause, what health consequences lack of estrogen has, how it affects bone metabolism, what exactly hormone replacement therapy is, and what benefits it has in post-menopausal women. Student will understand how estrogen affects uterine tissue growth and they will be able to explain how hormone replacement therapy works.

Transversal competencies

The training of transversal competences is necessary in the preparation of the professionals in pharmaceutical field. The inclusion of authentic and realistic clinic case-problem leads to a more robust learning activity. The advantages or benefits of PBL will lead students a greater motivation since they interact with reality, their learning will become more meaningful, favor the development of thinking and learning skills, promote the integration of a work model related to their future as pharmacist, enable greater retention of information, allow the integration of knowledge improving the understanding and promote an increase in student self-direction, collaborative work and teamwork.

Implementation of PBL

Several related to real physiopathological case-problem situations about ovarian dysfunction will prepare by lectures and present to the students in the UCM Virtual Campus. During the preparatory phase, implicated teachers will be oriented about PBL methodology and the clinical cases and tutor guides will be prepared. This combined strategy is varied, responding to the different ways of learning. It will help students to find answers to important questions related to disease processes such as what is the cause/causes of the disease, and why the disease is developing, what are the mechanisms responsible for disease onset, progression, and recover, or what are the mechanisms responsible for development of symptoms and signs of disease. The learning strategy is performed in different contexts and focuses more on the student and his learning than on the mere transmission of content, respecting the potential and uniqueness of the students. It provides opportunities for students to succeed in their learning, because it is well sequenced and fits depending on the characteristics of the students. It gives more importance to understanding meanings than to memorize concepts and allow students to make decisions in their development. To fulfil this aim student need to know and understand pathophysiological terms, essential pathological mechanisms to understand a pathologic process as event which influence the whole body which will achieve by self-learning previously to the session. Finally, the role of the teacher as facilitator will provide comments about potential responses to the questions, and enable students to evaluate answers and to think further about the issues. Also, they will help move the thinking or discussion further if students get stuck.

Developing Critical-Thinking

Critical thinking is one of the processes inherent in effective clinical judgment, there is a need to develop learning strategies that lead up to the formation and development it. Pharmacy educators are challenged to teach students to think critically, to go beyond simply "knowing," to advance to the synthesis and application of knowledge. The microscopy diagnosis from patients with ovarian dysfunction and the simulated setting on experimental animals provides a risk-free environment where learners can integrate theory and practice and think critically without the fear of harming patients or experimental animals. Using simulated computer learning experience as learning strategy will allow solving the case-problem and imitating the clinical environment leading to learners to demonstrate decision-making and critical thinking. It also provides of feedback to students for development of critical thinking. Students research the multiple ways information can be produced and how differently constructed perspectives and thoughts have been formed and how they are distinct from one another. Students will encourage attempting different ways to question and examine information, comprising arguments from factual data, and interpreting ambiguous or conflicting data. Assessing the credibility of information will be also practiced.

Encouraging Teamwork and Promoting Effective Interpersonal Skills

Students learn group-related skills and learn to utilize group collaboration to improve their own thinking. PBL demonstrate skills that result in effective information exchange by teaming to resolve the patients' case problem. The students gain collaborative experience not only through their group, but also through interaction between groups. It is also important that students learn how insight produced in different groups can be exploited for developing one's own learning and thinking. Thus, students learn to share responsibilities. Each member of a group has a role and is given a responsibility, which is known to all other group members. By this way, they learn to evaluate working methods and the goals than they reaches. The teacher aids students in forming a constructive and sincere collaborative atmosphere, with which students are able to

resolve differences and make compromises for reaching the mutual objectives. The practical activities will enable the students learn to produce and connect data, while simultaneously developing their own knowledge through this collaboration.

Acquiring Data by Self-learning

Previous and during the practical session students will cooperate in establishing collaborative processes for diverse data acquisition by combining various sources such as search engines, databases, personal bibliography, internet.... Students will learn to search and collect information in a focused and selective manner, while applying the acquired data to solve the real posed problem. Students will set their own learning and consider the ways these can be reached. Students will be given the opportunity to take initiative in planning and executing the practical activities to resolve the problem. Also, they will learn to evaluate their current knowledge and skills, and consequently learn to plan out their own feedback for future learning.

Professionalism

Students will be guided in practicing professional collaboration skills in such a way that enables students to apply those skills across their personal and academic lives. Students will garner work experience and begin to develop an understanding of the practical demands and expectations of professional life. Students will evaluate and compare their experiences. They will understand the meaning of commitment to carrying out professional responsibilities under diverse patient populations and face new and unexpected situations that professional life may throw at them. Students will also get to practice sustainable decision-making in real-life situations.

Evaluating the integrated learning method

To measure the impact of this new methodology on the students, we propose to use a voluntary survey according to Likert after the practice. We will propose a survey of 30 questions as is showed in Table 1. We will evaluate the transversal and curricular competences acquisition by student and the opinion of student about the applied methodology and teachers. The student's perceptions, attitudes, and opinions will be considered according 5 level scale taking into account five-point 1 to 5, being 1 'strongly disagree' and 5 'strongly agreeing' will be measured. The data will be collected, compiled, and statically analyzed.

CONCLUSIONS

The combined learning of PBL with the use of histological diagnosis and computer simulation of cases of female reproductive pathology will allow students to acquire clinic integrated knowledge and transversal skills that enable them to become future pharmacists. Students will apply of didactic knowledge to direct patient care activities. This strategy has been designed to encourage effective and efficient teaching across all disciplines of pathology. Students will achieve transversal competences such as creative and critical thinking, critical assessment and management skills, synthesize complex information clinically, interpersonal skills, teamwork, collaborative work, self-learning and feedback of their auto-learning

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Satisfaction student questionnaire relating to inclusion of PBL to the practical and simulation laboratory	
Table 1	Questions
	<i>Transversal competences</i>
1	Develops my ability to synthesize and analyze information
2	Develops my oral communication
3	Develops my listening ability
4	Increases my motivation and aptitude towards the subject
5	Promotes my ability to search for information
6	Improves my problem solving ability
7	Develops my critical reasoning ability
8	It improves my ability to understand information
9	Let take responsibility for my own learning
10	Awakens interest in the subject taught
11	It promotes autonomous learning
12	Promotes teamwork
13	I have actively participated in group work sessions
14	All the members of the group have worked equally
15	Encourage group discussion of issues and cases
16	It favors my skills in interpersonal relationships
17	Take advantage of the knowledge and experience of group members
	<i>Curricular competencies</i>
18	I learn new knowledge
19	I better understand the subject
20	Consolidates previous knowledge
21	It allows me to know my level of knowledge and learning
22	It has given me an integrated vision of different subjects
23	Matches contents between several subjects
	<i>About the methodology and teacher</i>
24	The instructions taught by the teacher are fundamental to my learning
25	The subject material has been well prepared and organized
26	helps me to plan and manage the time for the study of the subject
27	The work groups has been a good tool to learn the subject
28	Teaching strategies allow me to learn from case-problem
29	It is useful for my training as a pharmacist
30	My degree of satisfaction using this methodology is

PUBLICACIÓN 2

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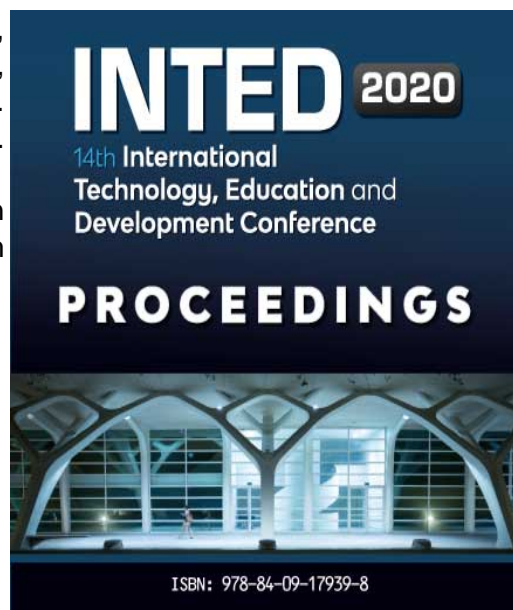
The positive impact of practical PBL lessons on student learning in female reproductive system pathophysiology.

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THE POSITIVE IMPACT OF PRACTICAL PBL LESSONS ON STUDENT LEARNING IN FEMALE REPRODUCTIVE SYSTEM PATHOPHYSIOLOGY

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This study investigates the efficiency of a novel integrated practical teaching methodology by combination of problem basic learning (PBL) with the physiopathology laboratory practices. The progressive resolution of a clinical case related to the ovarian dysfunction in a simulated environment by performing histological and clinical diagnosis from patients' biological samples were the basis of learning. The pathophysiological simulation was used as a virtual facilitating the resolution of case in the laboratory teaching practice. We aim that this integrated pedagogic methodology allows students to learn to solve professional reality problems by laboratory exercises and so improve students' overall understanding pathophysiological concepts. The present pilot experience was carried out in third-year undergraduate in Pathophysiology course of the Pharmacy Curriculum. Groups of 30-36 students were divided into smaller groups (n=3-4). Students solved the problem posed by 1) Identification of the phases of the ovarian cycle by histopathological analysis with optic microscopy; 2) Vaginal cytological diagnosis from patients with ovarian dysfunction posed in the problem case; 3) Study of the effects of the administration of estrogen or calcitonin as hormone replacement therapy to ovariectomized rats by using simulation PhysioEX 9.0 software. We compared two student groups: one group including PBL to conventional teaching and another one without PBL (Non-PBL). The efficiency of PBL inclusion to traditional practical lectures session was evaluated through the academic achievement of the students. Standardized multiple-choice questions examinations about posed patient cases related the pathohistological diagnosis, uterine cervix cytology diagnosis and

hormone replacement therapy, respectively, were performed. We found that the use of the PBL integrated teaching model led to a significant improvement in student performance on examinations. The results from the tests showed that the students were able to analyse and explain the effects of ovarian dysfunction, discuss the various variables that affect it, analyse the risks of the progression and development of this disease, critique diagnostic testing and determine its relationship to signs and symptoms. In summary, including PBL to the laboratory practical lectures improved the students' academic achievement and enhanced their critical thinking to understand the pathophysiologic principles of the ovarian dysfunction. We believe that the implementation of PBL integrated teaching model improves students' attitudes toward learning in professional context and could be adopted by instructors in similar courses in other professional grades.

Acknowledgment: This work is supported by PIMCD 159. Complutense University of Madrid. Spain

Keywords: Ovarian physiopathology, Problem based learning, Clinical diagnosis, Physiopathology simulation, Active integrated learning methodology,

[1] INTRODUCTION

In the present study, we investigated the impact that a change from a traditional discipline-based practical methodology to integrated PBL learning model had on student performance. The inclusion of PBL in Pharmacist curricula is considered one of the most efficient ways to enhance student learning, and it has been recognized as an effective way to prepare students for professional careers. Numerous studies have been conducted to assess the PBL concerning acquiring knowledge, development of core competencies and attitudes [1][2]. In addition, it well known that students exposed to a PBL curriculum tend to improve clinical issues and critical skills [3] and therefore the need to introduce it completely into the pharmaceutical curriculum is postulated [4]. The academic performance of pharmacy students have been found to be higher with PBL compared to traditional methods in some settings/course components [5]. So, the evaluation of the effects of the PBL approach, coupled with traditional methodologies, is necessary to consolidate it as an effective teaching tool for pharmacist students. We have designed an integrated teaching method that allows the interaction of several learning resources such as the study of clinical cases with student-led debates (PBL), virtual laboratories, and histological diagnostic practical classes for the study of female reproductive pathophysiology [6]. In the current work, we proposed to evaluate the efficiency of the implementation of PBL combined with active conventional learning methods through the measurement of student knowledge acquisition. From the students' questionnaires test, we demonstrated the efficiency of PBL as a new learning strategy integrated with the histological and uterine cervix diagnosis and computer simulations in a clinical case-based context.

[2] METHODOLOGY

Learning context and Participants

The Pathophysiology practical module is a compulsory taught in the third year of the pharmacy degree. Students must impart 1 ECTS credit. Students receive 3 hours of daily practice for 5 days along a week. The present pilot experience had been carried

out in groups of 30-36 students divided into smaller groups of 3-4 students. We have used the infrastructure of our department to deliver the proposed practice and implement a new integrated learning strategy module. 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 academic achievement of the students.

Materials and methods

The design of the inclusion of histological and uterine cervix cytology diagnosis and computer simulations in a case-based context as integrated PBL learning strategy into the Female reproductive system practical lesson has been previously described [6] (Figure 1). Several related to real physio pathological case-problem situations about female reproduction system plus basic questions, were presented to the students in the UCM Virtual Campus. The students are expected to find answers to the question, with learning resources provided in real-time in terms of internet access, articles and books, favoring the self-learning. During 3 hour session, students (n=3) solved the problem posed by interacting in an inquiry-based model to integrate self-generated laboratory data within clinical situations through 1) Identification of the phases of the ovarian cycle by histopathological analysis with optic microscopy; 2) Vaginal cytological diagnosis from patients with ovarian dysfunction posed in the problem case; 3) Study of the effects of the administration of estrogen or calcitonin as hormone replacement therapy to ovariectomized rats by using simulation PhysioEX 9.0 software [7]. Regarding the diagnosis practical activities, first the students received instructions in a guide containing the aims and the materials and methods of each experiment so that they could then guide themselves through it. The small students groups were oriented to work by themselves and afterwards to note their results and answer the discussion questions proposed by the professor in the guide. Feedback from the learning was done through the development of a Teacher's Guide. The extensive teaching experience of the teachers involved is a guarantee for the achievement of the learning objectives set [8][9][10][11][12].

Assessing knowledge enhancement

The assessment of the acquired knowledge consisted of a questionnaire of 30 items of which 6 questions corresponded to the practice of female reproductive system including 2 items based on each one of traditional practical curriculum topics: pathohistological diagnosis, uterine cervix cytology diagnosis, and simulation model about hormone replacement therapy. The contribution of the acquired knowledge from each topic of female reproductive system was relative to total score practical test.

Data Analysis

Statistical analyses and graphics of the data were performed by using of SPSS software (version 25.0, SPSS, Chicago, IL) and Graphpad Prim 6.0. Descriptive statistics were displayed in percentages and means \pm SEM. Experiments were designed to allow pairwise comparisons between the marks of practical tests reached by the non-PBL and PBL students. Comparison of the effectiveness of the mixed PBL method regarding students 'performance was done using independent t -test and a *P* value of ≤ 0.05 was taken as statistically significant.

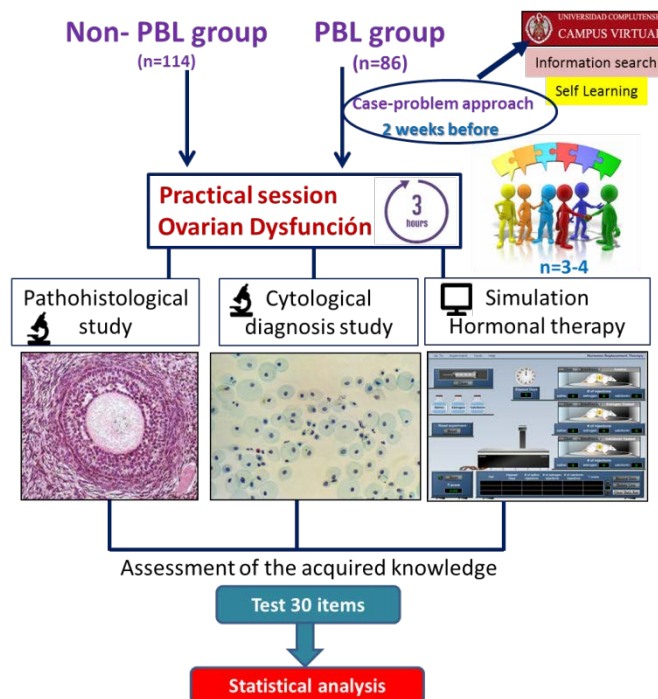


Figure 1: Experimental design to evaluate the assessment of the acquired knowledge by using the histological and uterine cervix diagnosis and computer simulations in a case-based context as integrated PBL learning strategy. Modified from Muñoz-Picos et al. 2019. [6]

RESULTS

Two cohorts of third-year Pharmacy students were compared. One hundred and fourteen non-PBL students and eighty six PBL-students responded and filled the practical final questionnaire to measure the achieved knowledge; 88.3% with age of 20–22 and the mean age was 20.7 ± 1.1 years. About two third of the class (72%) were females and 28% were males.

An achievement test (30 items) was used to evaluate the effectiveness of the implementation of PBL integrated teaching model, and identify the appropriate academic placement for students. Our assessment documented statistically and pragmatically significant effects.

a.- PBL-students achieved better performance on the scores of final practical test.

Figure 2 a) shows exam averages from all pathology questions of the practice from non-PBL and PBL groups. For the non-PBL students, the mean score was 6.64 ± 0.15 , with a range of 1 to 10; while for the PBL students, the mean score was 7.49 ± 1.77 , with a range of 3 to 10. The average rating significantly increased by 12.8%, $P= 0.0305$ (Paired t-test). The number of students who obtained the highest score (score=9.5-10)

in the PBL group (n=11) was much higher than in the non-PBL (n=5). In addition, the students' performance was assessed using a 0 to 10-point grading scale (Figure 2 b); and was expressed as percentage of students (%) who obtained each score. Data indicated that there were significant differences in the mean scores with both higher-, and lower-performances. Higher percentage of students in PBL-group rated high scores (7= non-PBL 12.28 vs PBL 22.72; 9= non-PBL 7.80 vs PBL 9.10; 10= non-PBL 6.10 vs PBL 12.50) compared to non-PBL. The percentage of students who obtained scores below <5 with poor performance was higher in non-PBL group (<5= non-PBL 18.42 vs PBL 13.43), showing the effectiveness of PBL strategy.

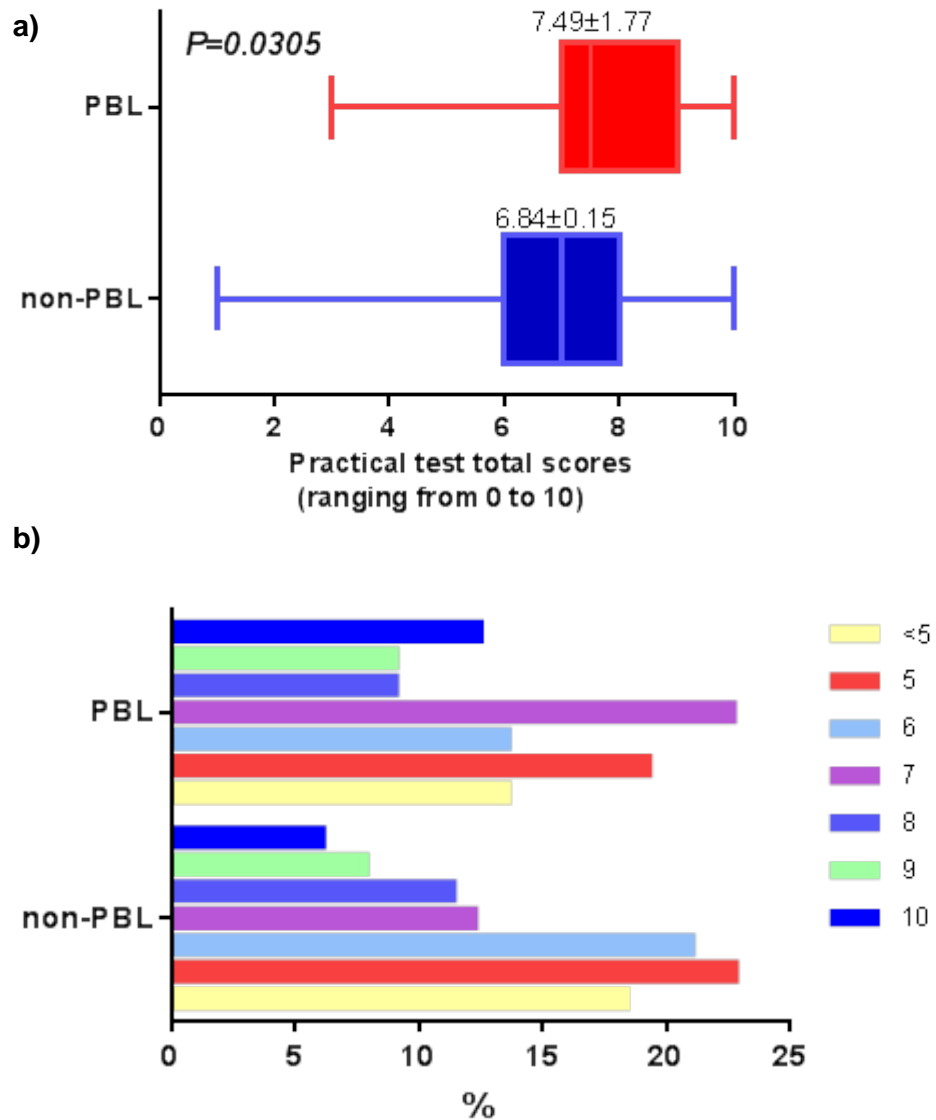


Figure.2: a) Final scores of the practical tests (mean \pm SEM) of non-PBL and PBL students. b) Percentage of students who have obtained scores <5 (poor performance) and between 5 and 10 (good or high performance) (%).

b.- Effectiveness of implementation of mixed practical PBL lesson on students' learning in relation to the female reproductive system pathophysiology.

The contribution of the mark in the practice of the female reproductive system to the total score of the final practice exam is shown in Figure 3. As consequence of the PBL inclusion, the percentage of contribution of practice questions to the final mark was higher than non-PBL(non-PBL=19.03±0.53 vs PBL= 21.99±0.67; $P=0.0006$), indicating that a major percentage of PBL student obtained better scores in the female reproductive system questions respect to the rest of the items compared to non-PBL.

Figure 3. Contribution of the reproductive female system practical score to the total score final test expressed by percentage (%).

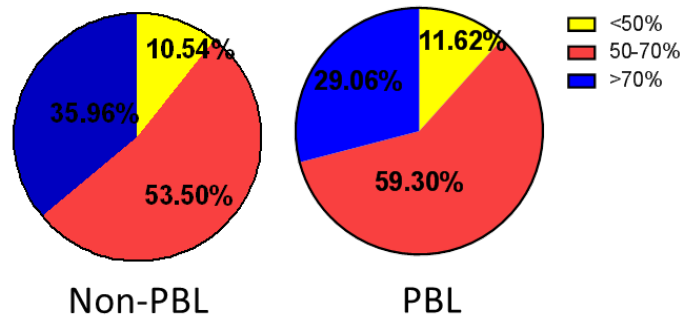
To know if the pathophysiological analysis with optic microscopy; the vaginal cytological diagnosis or the pathophysiological simulation teaching tools have been effective as a PBL integrated method, we studied the contribution of each one of them to the total score obtained in said practice. So Table 1 shows the number of students who have obtained scores below <50% (poor performance), between 50-70% (good performance) or >70% (high performance) in the questions about pathohistological diagnosis, uterine cervix cytology diagnosis, and hormone replacement therapy regarding the total number of questions answered, whereas Figure 4 represents these same data in percentage. The results showed that the use of pathophysiological analysis with optic microscopy of ovarium slices as a PBL-tool did not improve the results obtained by non-PBL students. However, uterine cervix cytological diagnostic led to a lower percentage of suspended students (non-PBL=8.77 vs PBL= 5.81) and a significant increase of the percentage of student who obtained scores between 50 to 70% (good performances) (non-PBL=58.77 vs PBL= 62.79). The combination of physiological simulation about the hormone replacement therapy with PBL was more effective, increasing the number de students with good-performance (non-PBL=52.63 vs PBL= 61.62) and higher-performance (non-PBL=25.43 vs PBL= 32.55) and

decreasing the percentage of students with scores below 50 (non-PBL=21.92 vs PBL= 5.81).

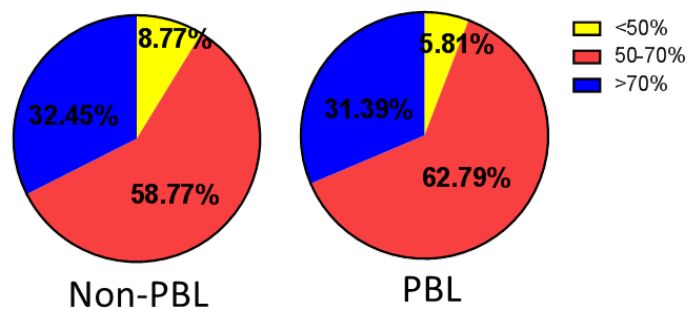
Table 1. Number of students who have obtained scores below <50% (poor performance), between 50-70% (good performance) or >70% (high performance) in the pathohistological diagnosis, uterine cervix cytology diagnosis, and hormone replacement therapy practice questions regarding the total number of questions answered.

	Non-PBL				PBL			
	<50%	50-70%	>70%	N	<50%	50-70%	>70%	N
Pathohistological diagnosis	12	61	41	114	10	51	25	86
Uterine cervix cytology diagnosis	10	67	37	114	5	54	27	86
Hormone replacement therapy	25	60	29	114	5	53	28	86

a) Pathohistological diagnosis



b) Uterine cervix cytology diagnosis



c) Hormone replacement therapy

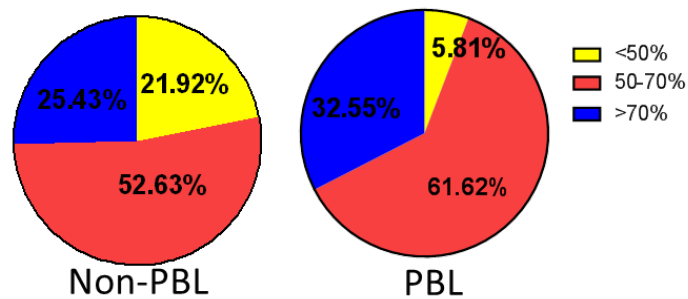


Figure 4. Percentage of students who have obtained scores below <50% (poor performance), between 50-70% (good performance) or >70% (high performance) in the a) pathohistological diagnosis, b) uterine cervix cytology diagnosis, and c) hormone replacement therapy practice questions regarding the total number of questions answered.

CONCLUSIONS

In this study, we evaluate how the change to a more integrated PBL methodology combined with other traditional pedagogical methods in the practical lessons impacted the performance of the students' exam. The inclusion PBL to practical curriculum

seems to improve the academic performance of pharmacy students when compared to the practical traditional methods. The PBL strategies prove to be effective in the students' overall and partial achievement. Specially, we found that a PBL integrated style curriculum promotes aspects of knowledge acquisition that are favorable in a clinical setting and those related to diagnosis. The integrated PBL style implementation prepared better for the questions that required the information to be analyzed and / or applied clinically. Thus, use of real life clinical cases and its resolution through the diagnosis of vaginal cytology and the simulation of hormone replacement therapy proved to be very effective and facilitated the potential practical skills of the students. The collection of results and their interpretation by students contributed to consolidate knowledge through reasoning and critical thinking leading to solve the clinic-case posed. These results suggest that incorporating the use of different PBL approaches can be a useful instructional strategy in the teaching and learning of pharmacists at university level. The designed mixed method could be conducted to reveal richer student perceptions of the problem-based experience.

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PUBLICACIÓN 3

V.S. Fernandes, M. Hernández-Martín, C. Contreras, M. Muñoz-Picos, C. Rodríguez-Prados, A. Agis-Torres, A. Sánchez, B. Climent, P. Recio, R. Raposo, S. Benedito, A. García-Sacristán, L. Rivera, D. Prieto, M. Hernández, M.E. López-Oliva.

Effect of a novel PBL-traditional learning strategy on students' knowledge acquisition in pathophysiology. A pre-test and post-test study.

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Editorial IARED Academy, España

EFFECT OF A NOVEL PBL-TRADITIONAL LEARNING STRATEGY ON STUDENTS' KNOWLEDGE ACQUISITION IN PATHOPHYSIOLOGY. A PRE-TEST AND POST-TEST STUDY.

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Objectives: The aim of this study was to determine the efficiency of the inclusion of Problem Based Learning (PBL) on practical traditional learning approaches on students' knowledge acquisition by using a quasi-experimental Pre-test and Post-test.

Background: The integration of practice curricula within Pharmacy degree is crucial in generating graduates capable of solving therapeutic problems. PBL is used as a strategy which allows to students to acquire knowledge through an active learning environment by training them to identify to solve real case-problems. We have designed a novel teaching tool with an academic-professional profile to improve students' ability to learn Physiology and Physiopathology subjects. This tool stimulates the student's integrated learning capacity by acquisition of fundamental practical and transversal skills to educate students of the Degree in Pharmacy.

Methods: The implementation of PBL combined with active conventional learning methods was applied to the Female Reproductive System practical lesson. Small groups of 3-4 students of a total of 74 second year Pharmacy students participated in this study. A case problems were designed and delivered in the Virtual Campus with enough time for its completion by self-learning using student's own bibliography. At the beginning of the practical session, all the students were given pre-test. Students solved the case-problem posed by a) identification of the phases of the ovarian cycle by histopathological analysis with optic microscopy; b) uterine cervix cytological diagnosis from patients; c) virtual computer simulation by using PhysioEX 9.0 software. At the end of the practical class, post-test with the same ten pre-test questions was conducted. The contribution of the acquired knowledge from each learning strategy

was relative to total score practical test as well as the total scores from pre- and post-test. Paired t-test, a repeated-measures ANOVA and Pearson's correlation coefficients were used to analyze the data obtained from pre- and post-test.

Results: Mixed PBL teaching strategy led a significant improvement in the post-test score, in the percentage of students who obtained the highest post-test score compared to pre-test ($P= 0.0001$) as well as a high pre-test/post-test correlation ($P= 0.0001$). Within-subjects repeated measure of ANOVA demonstrated an overall significant difference in the estimated marginal means and the effectiveness over time of each particular PBL mixed intervention. The contribution of both Pathohistological and Cytological diagnosis tools led to significant increases of the percentage of student who obtained scores high performances, the highest estimated marginal means and very high Pearson's correlations relative to the final and total pre- and post-test. Students using the PBL-computer simulation approach much better knowledge acquisition with the highest mean of scores in both tests, but the gain between pre- and post-test was not so effective.

Conclusion: The effectiveness of mixed PBL teaching strategy has been demonstrated. Pre-tests gave students a preview of what to expect from the female reproductive practical unit and of their previous knowledge acquired by self-study. The interaction between traditional learning resources and clinical cases with student-led debates improved the students' knowledge acquisition and achieved better student learning effects.

Key words: Pathophysiology; Knowledge acquisition; pre- post-test, Integrated PBL learning

INTRODUCTION

Problem Based Learning (PBL) is a teaching strategy used to promote active learning. It is considered effective in stimulating students to analyze, compare, contrast, synthesize, apply, explain information and integrate basic knowledge in the face of real-life situations [1]. PBL has been recommended for a variety of clinical subjects, especially in preclinical training in Health Sciences graduates [2]. PBL actively engages students in their own learning and includes the basic knowledge to enhance student learning such as carefully designed problems and discussion groups facilitated by a tutor [3]. Pharmacy graduates must be capable of conceptually understanding a clinical problem, and be able to apply their knowledge to solve real-world complex problems effectively [4]. For this purpose, we have designed an integrated teaching method that allows the interaction of several learning resources such as the study of clinical cases with student-led debates (PBL), virtual laboratories, and histological diagnostic practical classes for the study practical Pathophysiology and Physiology lessons [5,6,7]. We designed this teaching strategy to focus Pharmacy student learning on how to use scientific knowledge to solve key pathophysiology questions. We have previously evaluated the efficiency of the inclusion PBL to practical curriculum applied to students of second and third course of Pharmacy degree by the measurement of the student's academic performance at the final practical test. From these studies, we reported that the use of mixed PBL-traditional strategy during practical session improved students' ability to learn Pathophysiology [5] and Physiology [6]. In this study, we employed a single group pre-test and a post-test experiment design to test out the effectiveness of PBL intervention included to a conventional approach practical learning strategy. Pre-test/post-test provides measurement of change for assessing the impact of teaching

instruction during a time frame [8]. We analyzed students' prior knowledge by pre-test, in order to assure that the students' knowledge baseline did not differ that the experimental conditions with respect to the conventional practical lesson supported PBL. In addition, the contribution of the PBL inclusion to each included traditional teaching tool by the study of the gain of post-test respect to pre-test scores has been evaluated.

METHODOLOGY

Third-year Pharmacy students enrolled in a compulsory Physiopathology course (n = 74,67% female and 25,33% male) participated in this study as part of their normal coursework. Standard practical sessions (1 ECTS credit) were 3-h classes for 5 days along a week. The present pilot experience had been carried out in groups of about 30 students divided into smaller groups of 3-4 students. The implementation of PBL combined with active conventional learning methods through optic microscopy diagnosis and computer simulations as virtual laboratory, all of them integrated PBL learning strategy into the Female Reproductive System practical lesson (FRS), has been previously described [5,6]. Several related to real physiopathological case-problem situations about FRS plus pre-test questions were presented to the students in the UCM Virtual Campus. Students were expected to come prepared for practical sessions by reading the assigned practice script and finding answers to the question from pre-test, by using of learning resources provided in real-time in terms of internet access, articles and books and their favoring the self-learning. After this individual self-study period and during 3 hour practical session, students gather (n=3-4) and discuss what they have learned and come to an answer to the formulated learning issues to solve the problem without any prior instruction of how to do it. Therefore, the prepared problems by self-study have been used to activate students' prior knowledge. The discussion groups were facilitated by a teacher (i.e., so-called tutor) and aimed to acquire knowledge, to better understand the problem, and to acquire skills to solve the problem. Along the practical lesson, student solved the posed case-problem by interacting in an inquiry-based model to integrate self-generated laboratory data through a) Identification of the phases of the ovarian cycle by histopathological analysis with optic microscopy; b) Vaginal cytological diagnosis from patients with ovarian dysfunction posed in the problem case; c) Study of the effects of the administration of estrogen or calcitonin as hormone replacement therapy to ovariectomized rats by using simulation PhysioEX 9.0 software [9] (Figure1). The small students' groups were oriented to work by themselves and afterwards to note their results and answer the discussion questions proposed by the professor in the student's guide. The teacher's role was to facilitate the process of students' problem solving by keeping the discussion ongoing. This was achieved by different techniques: the teacher moved around the room while engaging the students and was active in inquiring, responding, role playing, and facilitating discussion. During the small-groups discussions, teachers gave feedback and discussed the misconceptions revealed by the formative pre-test. Feedback from the learning was done through the development of a Teacher's Guide. The extensive teaching experience of the teachers involved was a guarantee for the achievement of the learning objectives set [5-8][10-13]. To determine the students 'knowledge gain, at the end of practical lesson, post-test with the same ten pre-test questions were given to the students. The pre and post –tests were designed in such a manner that they followed the learning objectives of the lecture with subject topics. Performance of the PBL students' group on the pre- and post-tests was recorded for subsequent analysis. The study was designed as a quasi-experimental study using equivalent comparison-groups' pre-test-post-test design. The contribution of the

acquired knowledge from each topic of FRS was relative to total score practical test as well as the total scores from pre- and post-tests.

Data Analysis

Statistical analyses and graphics of the data were performed by using of SPSS software (version 25.0, SPSS, Chicago, IL) and Graphpad Prim 8.0. Descriptive statistics were displayed in percentages and means \pm SD. Experiments were designed to allow pairwise comparisons between the pre-test and post-test marks and the comparison of the effectiveness of the mixed PBL method regarding students 'performance was done using independent t-test. *P* value of ≤ 0.05 was taken as statistically significant. Because the pre-test and post-test contain student identifiers, the use of a repeated-measures ANOVA was included in comparing pre- and post-test results. Pearson's Correlation between pre-test and post-test have been calculated to demonstrate the stability of student test scores between two time points measurements.

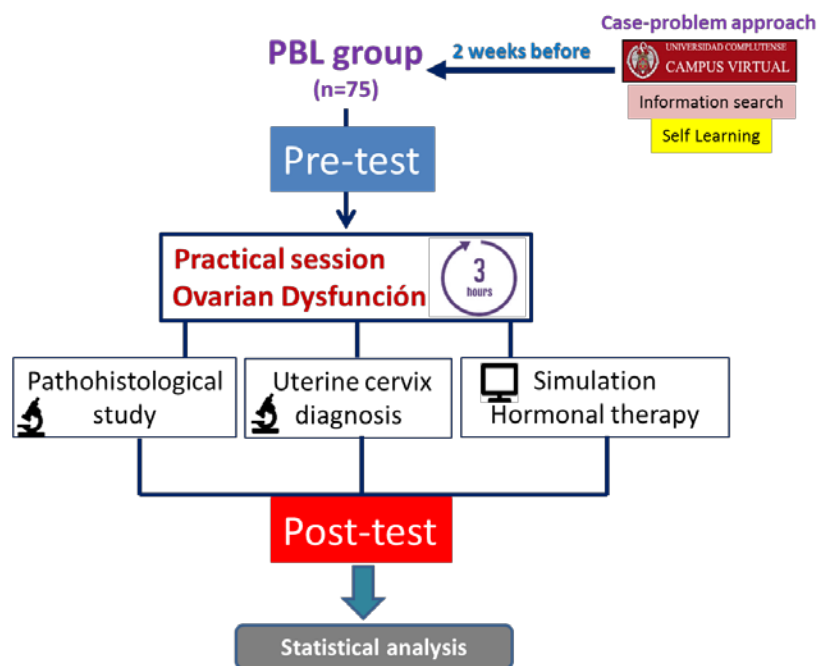


Figure 1: Experimental design to evaluate the assessment of the acquired knowledge by comparing the pre-test and post-test scores from the histological diagnosis, uterine cervix diagnosis and computer simulations in a case-based context as integrated PBL learning strategy. Modified from Muñoz-Picos et al. 2019. [7]

RESULTS

Pre-test and post-test quantitative data from PBL student were collected and analysed. Figure 2 a) shows the total scores from pre- and post-tests from all of students. We can observe that almost all pre-test scores were quite low compared to the post-test. The mean of pre-test score was 6.46 ± 0.19 with a range of 3 to 9; while for the post-test, the mean score was 7.96 ± 0.18 with a range of 4 to 10 (Figure 2 b)). This meant that the average rating significantly increased by 23%, $P= 0.0000$ (Paired t-test). Overall marks were improved in post-test, where majority of the students scored above five and few of them were low performers. The overall mean scores showed highly significant improvement in the post-test scores of all the students compared to their pre-test scores.

a)

Scores from exams

b)

Mean of scores

Figure.2: a) Individual pre- and post-test final scores b) Mean and standard deviation (mean \pm SD) from pre- and post-test scores.

Scatterplot in Figure 3 representing the relationship between pre- and post-test scores from 75 PBL-students participants showed that there was a positive relationship between the distributions of scores, so students with highest scores on the pre-test also had high scores on the post-test. Points above the one to one line indicated an improvement of score after PBL intervention. The correlation between pre-test and post-test scores within the PBL group provides an estimate of the consistency of the treatment effect across individuals. In this study the pre-test-post-test scores correlation was high ($r=0.925$, $P= 0.0001$) showed that the rank ordering of students on the pre-test was similar to rank ordering of students on the post-test and so the effect of PBL was similar for every individual.

posttest

Figure 3. Scatter plot of pre- and post-test final scores from all student participants (n=75).

In addition, the students' performance was assessed using a 0 to 10-point grading scale and was expressed as percentage of students (%) who obtained each score (Figure 4). The number of students who obtained the highest score increased significantly in the post-test respect pre-test scores (pre-test vs post-test, score 9; 5.3 vs 26.6, score 10; 0 vs 12.0). Higher percentage of students in pre-test obtained a grade of 8 while, in the post-test, the highest score percentage was of 9. The number of students (%) who obtained scores below <5 with, poor performance, was higher in pre-test (pre-test vs post-test, scores <5.1 vs 6.6). These results show the effectiveness of PBL strategy.

Figure 4. Percentage of students who have obtained scores <5 (poor performance) and between 5 and 10 (good or high performance) (%) in the pre- and post-tests.

Figure 5 represents the percentage of student which obtained scores below <50% (poor performance), between 50-70% (good performance) or >70% (high performance) in the pre-test and post-test questions related to the total number of questions answered in the final test (Figure 5a). Also, it shows the answered questions about the pathohistological diagnosis (Figure 5b), uterine cervix cytology diagnosis (Figure 5c), and hormone replacement therapy by computer simulation (Figure 5d) learning instructions. A paired samples-test (N=75) resulted significant differences between pre- and post-test scores showing that there was a large and differential PBL learning effect in each intervention. The PBL inclusion to both pathohistological (Figure 5b) and uterine cervix cytological (Figure 5c) diagnosis tools led to a lower percentage of suspended students (pathohistology; pre-test=53.57 vs. post-test= 16.28; uterine cervix cytology: pre-test=25.00 vs. post-test= 11.62) and a significant increase of the percentage of students who obtained scores >75% (high performances) (pathohistology; pre-test=5.95 vs post-test= 36.04, uterine cervix cytology; pre-test=25.00 vs. post-test= 51.16). These results contributed greatly to the improvement of the scores achieved by the students in the final test in which increased the number of students with higher-performance (pre-test=11.90 vs. post-test= 4.65) and decreased the percentage of students with scores below 50 (pre-test=30.95 vs. post-

test= 46.51) (Figure 5a). However, the combination of physiological simulation about the hormone replacement therapy by simulation as a PBL- learning tool was less effective. The results showed the percentage of number of students did not improve the scores obtained in the post-test vs. pre-test (<50; pre-test=5.95 vs. post-test= 5.81; between 50-75; pre-test=47.61 vs. post-test= 41.86, >75; pre-test=46.42 vs. post-test= 52.32) (Figure 5d).

Therefore, we studied which of the traditional teaching tools integrated as a PBL method contributed the most to improve the post-test versus the pre-test. Statistical analyses were conducted to evaluate the statistical differences between the pre-test and post-test results using Repeated Measure of One-way Analysis of Variance (ANOVA) on PBL teaching tools with the alpha level 0.05. Tables 1 and 2 provide an overview of the descriptive statistics of the pre- and post-test scores of all instruction groups. Mauchly's Test of Sphericity findings presented in Table 1 demonstrated that the significance level was not calculated (null) for the all teaching tool used (Table 1 shows only data from the final test scores). In this case, the assumption of sphericity was not confirmed and the probability of making Type 1 error increased. To eliminate this problem and to know if the mean scores differences among the pre-test and post-test were statistically significant or not, data of Within-Subjects effects were checked (Table 2). Thus, we may notice a significant difference between the pre-test and post-test scores from Pathohistology diagnosis $F(30.82, 0.03)=853.30$; $P=0.000$, uterine cervix cytology $F(10.14, 0.12)=82.36$; $P=0.000$, Hormone therapy substitutive $F(0.20, 0.02)=6.86$, $P=0.011$ and scores from the total final practical exams $F(84.37,0.19)=423.30$, $P=0.000$. The overall significant difference in means was significant because the P value associated with F was 0.00000, which is less than 0.01 level of significance. It was observed that the post-test achievement scores were higher when compared to the pre-test scores. It may therefore be concluded that the PBL strategy had a significant impact on the pre-test and post-test academic achievement scores.

As seen in the graph presented in Figure 6, the estimated marginal mean increases in pathohistology diagnosis pre-test scores were significantly smaller than that observed in the other tools, achieving the mean of uterine cervix cytology tool scores and Hormone therapy substitutive tools in the post-test. The group averages that were separated from each other in the pre-test, obtained similar closed means in the post-test. In addition, correlation coefficients (r Pearson's coefficient) between pre-test and post-test were used as an indication of relative consistency of ranks of the samples (Table 3). The results confirmed that there were a high and significant Pearson's coefficients between pre-test-post-test for all the samples. The pre-test-post-test correlations of the computer simulation tools were the smallest, reducing statistical power for impact studied (ranged $r= 0.692$ to 0.588 , $P=0.01$).

Figure 5. Percentage of students who have obtained scores below <50% (poor performance), between 50-70% (good performance) or >70% (high performance) in the a) total final tests b) pathohistological diagnosis, c) uterine cervix cytology diagnosis, and d) hormone replacement therapy by computer simulation pre and post-test questions.

Table 1: Mauchly's Test of Sphericity Findings

Measure: Final test scores							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	gl	Sig.	Épsilon ^b Greenhouse-Geisser	Huynh-Feldt	Lower-bound
scores	1,000	0,000	0		1,000	1,000	1,000

Table 2: Repeated Measures ANOVA Findings Based on PBL experimental Group Mean Pre-test and Post-test Academic Achievement Scores

Final tests source		Type III sum of squares	df	Mean square	f	Sig.
scores	Sphericity Assumed	84,375	1	84,375	423,305	0,000
	Greenhouse-Geisser	84,375	1,000	84,375	423,305	0,000
	Huynh-Feldt	84,375	1,000	84,375	423,305	0,000
	Lower-bound	84,375	1,000	84,375	423,305	0,000
Error(marks)	Sphericity Assumed	14,750	74	0,199		
	Greenhouse-Geisser	14,750	74,000	0,199		
	Huynh-Feldt	14,750	74,000	0,199		
	Lower-bound	14,750	74,000	0,199		
Pathohistology diagnosis sources		Type III sum of squares	df	Mean square	f	Sig.
scores	Sphericity Assumed	30,827	1	30,827	853,307	0,000
	Greenhouse-Geisser	30,827	1,000	30,827	853,307	0,000
	Huynh-Feldt	30,827	1,000	30,827	853,307	0,000
	Lower-bound	30,827	1,000	30,827	853,307	0,000
Error(scores)	Sphericity Assumed	2,673	74	0,036		
	Greenhouse-Geisser	2,673	74,000	0,036		
	Huynh-Feldt	2,673	74,000	0,036		
	Lower-bound	2,673	74,000	0,036		
Uterine cytology diagnosis sources		Type III sum of squares	df	Mean square	f	Sig.
scores	Sphericity Assumed	10,140	1	10,140	82,367	0,000
	Greenhouse-Geisser	10,140	1,000	10,140	82,367	0,000
	Huynh-Feldt	10,140	1,000	10,140	82,367	0,000
	Lower-bound	10,140	1,000	10,140	82,367	0,000
Error(scores)	Sphericity Assumed	9,110	74	0,123		
	Greenhouse-Geisser	9,110	74,000	0,123		
	Huynh-Feldt	9,110	74,000	0,123		
	Lower-bound	9,110	74,000	0,123		

Hormone therapy substitutive sources		Type sum squares	III of df	Mean square	f	Sig.
scores	Sphericity Assumed	0,202	1	0,202	6,867	0,011
	Greenhouse-Geisser	0,202	1,000	0,202	6,867	0,011
	Huynh-Feldt	0,202	1,000	0,202	6,867	0,011
	Lower-bound	0,202	1,000	0,202	6,867	0,011
Error(scores)	Sphericity Assumed	2,173	74	0,029		
	Greenhouse-Geisser	2,173	74,000	0,029		
	Huynh-Feldt	2,173	74,000	0,029		
	Lower-bound	2,173	74,000	0,029		

Estimated marginal means

Estimated marginal means

Figure 6- Estimated marginal means for a) total final tests and b) the interaction between pathohistological diagnosis, uterine cervix cytology diagnosis, and hormone replacement therapy by computer simulation learning tools.

Table 3: Pearson's coefficients between total pre-test and post-test scores, the pathohistological diagnosis, uterine cervix cytology diagnosis, and hormone replacement therapy by computer simulation learning tools pre and post-test scores and final practical marks.

Pearson's coefficients (r)	Total pretest score	Pathohistology diagnosis pretest score	Uterine cytology diagnosis pretest score	Hormone therapy computer pretest score	Total posttest score	Pathohistology diagnosis posttest score	Uterine cytology diagnosis posttest score	Hormone therapy computer posttest score	Total practical mark
Total pretest score	1	,957***	,929***	,900***	,953***	,936***	,908***	,554**	,970***
Pathohistology diagnosis pretest score	,957***	1	,847**	,858**	,929***	,946***	,909***	,481**	,923***
Uterine cytology diagnosis pretest score	,929***	,847**	1	,855**	,889**	,843**	,831**	,524**	,937***
Hormone therapy computer pretest score	,900***	,858**	,855**	1	,922***	,902***	,917***	,694**	,896**
Total posttest score	,953***	,929***	,889**	,922***	1	,928***	,919***	,672**	,938***
Pathohistology diagnosis posttest score	,936***	,946***	,843**	,902***	,928***	1	,939***	,577**	,903***
Uterine cytology diagnosis posttest score	,908***	,909***	,831**	,917***	,919***	,939***	1	,576**	,876**
Hormone therapy computer posttest score	,554**	,481**	,524**	,694**	,672**	,577**	,576**	1	,588**
Total practical mark	,970***	,923***	,937***	,896**	,938***	,903***	,876**	,588**	1

***: P<0,001 ; ** P< 0,01.

CONCLUSIONS

Based on these results, it is concluded that PBL had a positive impact as evidenced with pre-test and post-test findings. Students had high knowledge acquisition in all the aspect of principles and procedures from traditional learning tools. PBL was able to enhance student's ability to apply knowledge through group brainstorming and discussion session. Students were actively involved in learning and retained information longer than when they were passive recipients of instructions. PBL increased the student's ability to integrate information from different topics and to apply such integrated content knowledge by solving clinical problems. Pre-post testing showed the students' individual academic gain in a longitudinal study, providing the chance to measure how approaches to learning could change over time. Pre-testing allowed to know the accurate knowledge baseline of the student upon entry to the instruction and gave students a preview of what to expect from the Female Reproductive practical unit. In addition, pre-test exposed students to new terms, concepts, and ideas and could be used as unit introductions. Students felt more comfortable with material that was familiar to them. Pre-tests allowed teachers to see levels of proficiency for each student and measure the degree to which students meets expectations using just prior knowledge. The mean of pre-test scores indicated that students were in fact in the initial phase of skill acquisition. The diagnostic teaching practices tools facilitated the resolution of posed case, at the same time that developed a range of practical competencies based in the area of laboratory skills. The Computer based learning plus PBL tool was less efficiency because students already displayed high scores in the pre-test, resulting a less gain from pre-test to post-test. A limitation of this study was that included only one group (i.e., no control group) by a longitudinal quasi-experimental study with measures before (pre-test) and after (post-test) the treatment. Only intrasubject comparisons have been used due to which no clear comparisons may be made. In spite of the such constraint, we can conclude that this

innovative teaching method enhanced student's ability to integrate information from different traditional learning topics and to apply such integrated knowledge content by solving clinical problems. The inclusion of problem based learning (PBL) with the laboratory practices of Pathophysiology in Pharmacy curricula could be a better teaching strategy that ensures graduate competence in critical thinking and problem solving. In addition, the novel integrative teaching strategy is focused student learning on how to use scientific knowledge to solve key pathophysiology questions.

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The potential for a new PBL integrated with simulations and laboratory diagnosis tool in pharmacy education. A questionnaire-based study. ICERI2020 Proceedings En prensa 2020 Editorial IARED Academy, España

THE POTENTIAL FOR A NEW PBL INTEGRATED WITH SIMULATIONS AND LABORATORY DIAGNOSIS TOOL IN PHARMACY EDUCATION. A QUESTIONNAIRE-BASED STUDY.

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Abstract

Objective: This study evaluates the impact of PBL-based blended learning with traditional teaching in the practicum of Pathophysiology course at the Faculty of Pharmacy, Complutense University of Madrid, by assessing students' satisfaction survey.

Methods: 51 third year undergraduate pharmacy students of pathophysiology were divided in small groups of 12 students each. They were exposed to PBL activities led by teacher as facilitators. Clinical real situations related to the female reproductive system as case-problem were presented in the Virtual Campus. Students were provided with clear guidelines for aims and objectives of the debate and related questions for the development of the practice. One week later, on the day of the practical session, students analysed the clinical problems, formulated hypothesis, and undertaken self-directed learning tasks. In addition, the PhysioEX 9.0 software allowed students to use a simulation virtual laboratory where they evaluated the hormone replacement therapy to ovariectomized rats as a replica of actual case-problem. Also, histological diagnosis of the ovarian slices was carried out. In addition, vaginal cytological diagnosis from patients were diagnosed by optical microscopy and related with ovarian dysfunction posed in the problem case. At the end of the week, the students completed a questionnaire regarding their PBL experience and on the suitability of each of the different materials used, as well as the attitudes generated by the implementation of the PBL system in the pathophysiology practical teaching. An anonymous survey was completed by the students and analysed by using the Likert's scale. We classified the survey questions into three sections by competences: transversal competences, curricular competences and methodological and teaching competences and correlated each item with the grouped competences.

Result: The obtained results indicated that the incorporation of PBL as a learning strategy in the pathophysiology practices had a positive impact on learning. The curricular competence was the best valued by the student. The use of simulation and the histological diagnosis coupled to PBL improved the acquisition of critical assessment and management skills, increased the interest and involvement of students in their own learning, encouraged participation among work teams, generated a critical thinking of greater clarity for the acquisition of new competences and allowed feedback of learning (self-evaluation). Thus, the student will deepen the practical pathophysiological mechanisms that are the basis of their knowledge as future pharmacists, which will allow them to propose effective therapeutic strategies. All this PBL mixed methodology experience will help to better understand an integrating vision and multidisciplinary way to teach pathophysiology practical lessons.

Keywords: Problem based learning (PBL) mixed tools, Pathophysiology practical lesson, histopathological diagnosis, campus virtual, and simulation.

INTRODUCTION

Pharmacy education must be in line with pharmacy-training needs to prepare professionals for clinical practices [1]. The teaching practical physiology curriculum provides students with necessary understanding, knowledge, skills, behaviors, and attitudes that prepare them for professional practice and enable them to be good practicing pharmacists [3]. The practical pathophysiology program of Pharmacy degree of Complutense of Madrid (UCM) provides students with the opportunity to gain a first-hand laboratory experience of the dysfunction of female digestive system. Taking an integrative teaching methodology approach, the students enable to gain a detailed understanding of the processes involved in how the body works in health and in disease.

We have designed a learning of female reproductive system pathophysiology developing a range of practical competencies based in the area of laboratory skills by using several teaching methods. Also, by using the PhysioEX 9.0 software, students learned under a simulation virtual laboratory [3,4]. The use of model and histological slides helps to consolidate basic knowledge necessary to learn pathophysiology [5]. In the addition, Problem-based learning (PBL) is an excellent tool for the development of analytical and organization capacities, decisions, task planning and problems [6,7]. We have designed an integrated teaching method that allows the interaction of several learning resources such as the study of clinical cases with student-led debates (PBL), virtual laboratories, and histological diagnostic practical classes for the study practical Pathophysiology and Physiology lessons [7,8,9,10]. We have previously evaluated the efficiency of the inclusion PBL to practical curriculum applied to students of second and third course of Pharmacy degree by the measurement of the student's academic performance at the final practical test. From these studies, we reported that the use of mixed PBL-traditional strategy during practical session improved students' ability to learn Pathophysiology [11,12] and Physiology [13,14], employing a single group pre-test and a post-test experiment design to test out the effectiveness of PBL intervention included to a conventional approach practical learning strategy.

The goal of this study was to assess the efficiency of the novel PBL mixed learning strategy by evaluating the student satisfaction surveys. We demonstrated that a combination of teaching methods encourage for effective and efficient teaching and improves the motivation of students for professional and clinical learning that enables them for the pharmaceutical profession

METHODOLOGY

Context and participants

For this study, the students of the pathophysiology, which is a basic subject of the third year of the PharmD curriculum, were recruited. Pathophysiology is taught in the first semester of the course. The Pathophysiology practical module consists of 5 practical sessions with a total of 15 hours long (0.4 ECTS credit) which are imparting during 3 hours every day along a week. The present pilot experience has been carried out in groups of 30-36 students divided into smaller groups of 8 to 10 8-10 students in the Pathophysiology practical sessions. Our Department of Physiology incorporated PBL/small group learning in the laboratory session about female reproductive system. We expected that the combination of PBL of female reproductive pathology's cases with the use of both histological diagnosis and computer simulation learning methods help students to achieve meaningful learning.

Preparation of teaching materials

Several related to real pathophysiological case-problem situations about female reproduction system were prepared by lectures and presented to the students in the UCM Virtual Campus. We have utilized the existing Physiology department and Pharmacy faculty infrastructure to design and implement a PBL module. Implicated teachers were oriented about PBL methodology and the clinical case and tutor guides were prepared. In relation to the diagnosis practical activities with microscopic histopathology and cytosolic diagnostic as part of their pathology training, students received instructions in a guide containing the aims and the materials and methods of each experiment, so that they could then guide themselves through it. Students worked by themselves in small groups and afterwards to note their results and answer the discussion questions proposed by the professor in the guide. Feedback from the learning was performed 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 student guide was made with the contents related to a) Identification of the phases of the ovarian cycle by histopathological analysis with optic microscopy; b) Vaginal cytological diagnosis from patients with ovarian dysfunction posed in the problem case; c) Study of the effects of the administration of estrogen or calcitonin as hormone replacement therapy to ovariectomized rats by using simulation PhysioEX 9.0 software [9] (Figure1). Practice Guidelines for the students were designed with related questions for the development of the practice and the use of it was valued.

PBL mixed methodology implementation

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 self-learning using bibliography on their own and answered the questions about the case. Thus, before the practical session students analyzed a real case-clinic, and formulated hypothesis by understanding self-directed learning tasks (physiology books, videos, PowerPoint slides, online resources, etc.....). Students were provided with clear guidelines for aims of the debate and related questions for the development of the practice session. In each session, a moderator in charge for controlling the time of the session ensured the participation of the rest of the students and a "notary" 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. In addition, students consolidated and searched for the answers to the questions of the clinical case, by carrying out the virtual simulation and diagnostic by studying the histological sections under an optical microscope. This served as a feedback mechanism for the self-learning carried out by students. The teacher had a passive role, resolving doubts derived from debate and the discussion of the case. Students had an active role discussing pathophysiological aspects and providing ideas.

Questionary

After the students completed the practical session, the teacher sent students a link via e-mail to an anonymous online survey. Table 1 shows the survey questions about the efficiency of PBL inclusion to diverse teaching and learning strategies. The survey consists of 20 items representing these 3 factors. These 20 items are presented in a Likert-type fashion, asking students to indicate their level of agreement with the given statement (strongly disagree, disagree, etc.).

Table 1	Student questionnaire relating to inclusion of PBL to the practical and simulation laboratory
Questions	Transversal competences
Q1	Develops my ability to synthesize and analyze information
Q2	Promotes my ability to search for information
Q3	Improves my problem solving ability
Q4	Increases my motivation and aptitude towards the subject
Q5	It favors my skills in interpersonal relationships
Q6	I have actively participated in group work sessions
Q7	It promotes autonomous learning
Q8	Develops my critical reasoning ability
	Curricular competences
Q9	I better understand the subject
Q10	Awakens interest in the subject taught
Q11	I learn new knowledge
Q12	Consolidates previous knowledge
Q13	It is useful for my training as a pharmacist
	About the methodology and teaching
Q14	Identification of the ovarian dysfunction by microscopic study helped me solve the posed questions asked
Q15	Uterine Cervix Cytology Diagnosis helped me solve the posed questions asked
Q16	Hormone replacement therapy simulation helped me solve the posed questions asked
Q17	The instructions taught by the teacher are fundamental to my learning
Q18	Teaching strategies allow me to learn from case-problem
Q19	This PBL integrated methodology approach facilitates understanding of the objectives proposed
Q20	My degree of satisfaction using this methodology is

Evaluation of the PBL mixed learning method

The assessment of efficiency of the PBL integrated method was carried out a student satisfaction questioner after the practice. The survey consists of 20 items representing these 3 factors. These 20 items are presented in a Likert-type fashion, asking students to indicate their level of agreement with the given statement. The students had to classify numerically to each item, taking into account a five-point Likert scale of 1 to 5, being 1 'strongly disagree' and 5 'strongly agreeing'. Items were classified in three groups; Transversal competences, Curricular competences and methodology and teaching questions. The data was collected, compiled, and analyzed by using of SPSS software (version 25.0, SPSS, Chicago, IL) and Graphpad Prim 8.0. Statistical tests were run with an α -level of 0.05. Also, we analysed the overall total survey with regard to transversal, curricular, and methodology and teaching competences. Internal consistency was assessed by Cronbach's alpha coefficient

RESULTS

Integrated exposure of students to PBL learning, combined to virtual laboratories and histological diagnosis tools as a new teaching methodology improves the student's understanding of pathophysiology, stimulates its study and increases interest by the students. We classify the survey questions into three sections: transversal competences, curricular competences and methodological and teaching competences and correlated each item with the grouped competences. Responses are given in Table 1 (median, variance, standard deviation, Cronbach's alpha, chi-square value and p value). Cronbach alpha coefficient for the final three subscales were $r=0.851$ (transversal); $r= 0.765$ (curricular) and $r= 0.831$ (methodology and teacher) and the alpha for the entire instrument was $r = 0.923$, suggesting that the items have relatively high internal consistency.

Table 1: Descriptive Statistics for the total items and each competence.

Total competences	Mean	Variance	Std. Deviation	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Friedman's Chi-Square	Sig	N of Items
Transversal	20,078	31,194	5,585	0,851	0,851	18,884	0,009	8
Curricular	14,353	10,793	3,285	0,765	0,764	10,232	0,037	5
Methodology and teaching	18,824	20,308	4,506	0,831	0,830	16,864	0,010	7
Total items	53,255	146,194	12,091	0,923	0,922	76,956	0,000	20

We classify the survey questions into three sections. Figure 1 represents the Likert' scale a) degree of satisfaction, b) in percentage calculated from the survey ($n=51$), c) the summary items statistic, and d) distribution histogram relative to the student satisfaction answers about the transversal competences. Students perceived acceptable levels of development of transversal competences, with total mean scores of 2.5 (Figure 1c). Questions 2, 7 and 8 were the best rated items. In the analysis of question 2 referred to whether the mixed PBL mixed method promotes student's ability to search for information, the students' scores were 45.1% (agreed) and 13.7% (strongly agreed). In the analysis of question 7 (It promotes autonomous learning) and 8 (It develops student's critical reasoning ability), the distribution of responses on the Likert scale was significantly higher in the agreed/strongly scores ($Q7=45.1/17.6\%$, and $Q8=39.2/19.6\%$), respectively. By contrast, the competence showing the lowest levels was the question 4 about the increase student's motivation and aptitude toward the subject ($Q4=21.6/15.7\%$). The majority of the students believed that the combination of this multidisciplinary teaching methods coupled to PBL teaching enhanced improved the acquisition of critical assessment and management skills, increased the interest and involvement of students in their own learning and encouraged participation among work teams. Over 60% of students felt that this method solving cases helped them to search for information and sharpen creative and critical thinking skills and synthesize complex clinical information. Only a 37% of students are agreed/strongly agreed that case studies focused on clinically significant learning issues and increase the motivation and aptitude about the subject.

Figure 2 represents the results relative to the curricular competences. The mean of Likert' scale scores from curricular competence questions was a little bit higher than that found in the transversal competence questions (curricular competences mean=2.87). The positive percentages of response (agreed, strongly agreed) of satisfaction of the students obtained for each questions related to the curriculum and the acquisition of knowledge were significantly high, although the average was not respect other competences. Student understood better de subject, (43.1% (agreed) and 27.5% (strongly agreed); learn new knowledge (45.1% (agreed) and 33.3% (strongly agreed), consolidate previous knowledge (51.1% (agreed) and 25.5% (strongly agreed), considered that it is useful for their training as a pharmacist (49.0% (agreed) and 19.6% (strongly agreed). The in-class group discussion/activities helped them take

responsibility for their own learning, and enhanced their overall learning. By contrast, question 10 was the competence showing the lowest levels, however a 55% of student felt that the PBL mixed method motivated and awaked interest in the subject taught. In general, curricular competences were the better valued by the students.

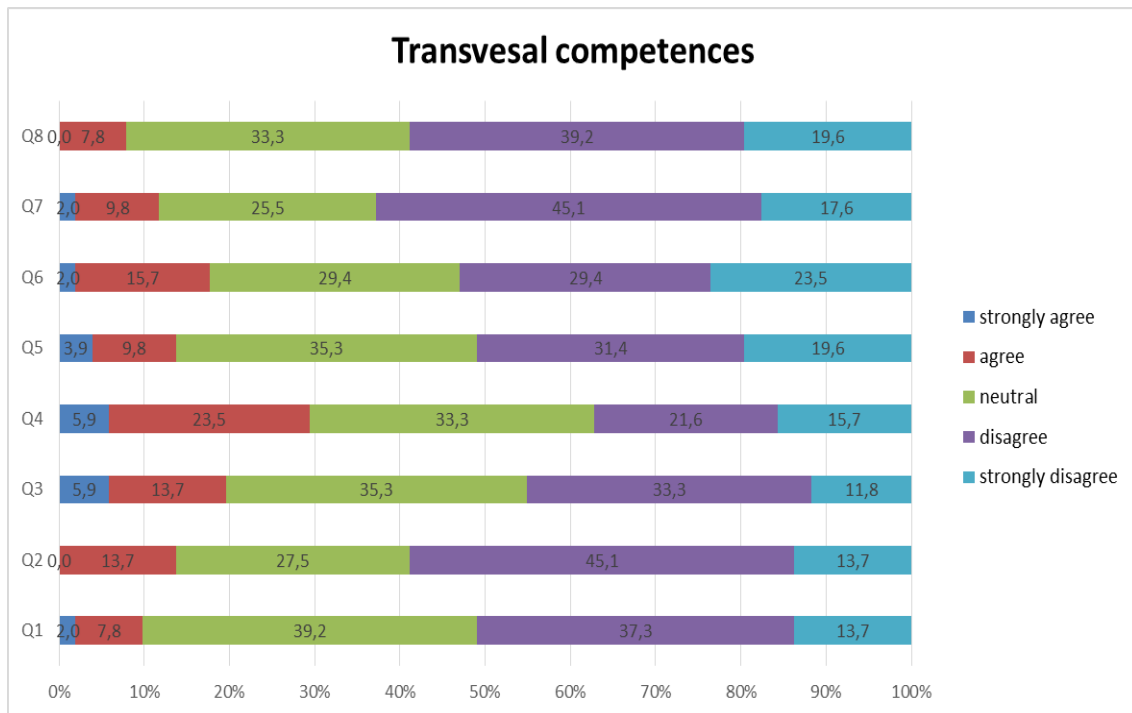
Figure 3 shows valuation the methodology and teaching competences in the student's satisfaction survey. The students considered that the diagnosis by optical microscopy (Q14= 49.0% (agreed) and 13.7% (strongly agreed)) and the use of computer in the hormone replacement therapy simulation (Q= Q16=41.2% (agreed) and 21.6% (strongly agreed)) helped them to solve the clinic case posed. The uterine cervix cytology diagnosis was less valued with a total of 52.9% positive opinions (Q=15 35.3% (agreed) and 17.6% (strongly agreed)). A 56.9% of students indicated the inclusion of case-problem as a PBL mixed strategy helped the student to solve the asked questions (Q18=41.2% (agreed) and 15.7% (strongly agreed)).(Surprisingly, 80.4% students think that they need the explanation and the teacher's intervention to be able to solve the objectives of the practice (Q17= 54.90% (agreed) and 25.5% (strongly agreed)). Students manifested their satisfied with the role of the teacher who works as their facilitator. Finally, the Q19 and Q20 questions about the efficiency of this novel PBL methodology were well valued which satisfaction scores of agreed and strongly agreed of 56.9% and 52.9% indicating the indicating the good acceptance of the method by the students. The fact that students have a better opinion on the acquisition of curricular competences with respect to the transversal or teaching competences by using PBL mixed method is related to previous results found by us. In this paper, we reported that the students achieved higher scores in the result of the exams practical exams compared to the students who have not received the mixed teaching with PBL. Beside we found increased in the marks between the pre and post-tests in PBL students.

Figure 1. Student's satisfaction survey. Results from the students on the voluntary opinion survey related to the combination of PBL with traditional practical learning about transversal competences. a) the Likert' scale score b) Likert' scale score in percentage calculated from the survey c) the summary items statistic, and d) distribution histogram (n=51).

a)

Questions	Transversal competences	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
1	Develops my ability to synthesize and analyze information	1	4	20	19	7
2	Promotes my ability to search for information	0	7	14	23	7
3	Improves my problem solving ability	3	7	18	17	6
4	Increases my motivation and aptitude towards the subject	3	12	17	11	8
5	It favors my skills in interpersonal relationships	2	5	18	16	10
6	I have actively participated in group work sessions	1	8	15	15	12
7	It promotes autonomous learning	1	5	13	23	9
8	Develops my critical reasoning ability	0	4	17	20	10

b)



c)

Summary transversal competences Items Statistics							
	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2,510	2,176	2,706	0,529	1,243	0,032	8
Item Variances	0,996	0,772	1,308	0,536	1,695	0,039	8
Inter-Item Covariances	0,415	0,120	0,764	0,644	6,363	0,022	8
Inter-Item Correlations	0,417	0,120	0,645	0,525	5,356	0,016	8

d)

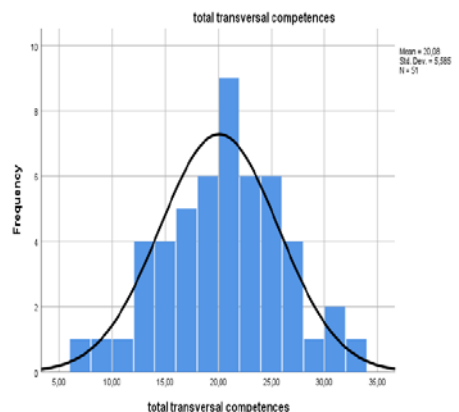
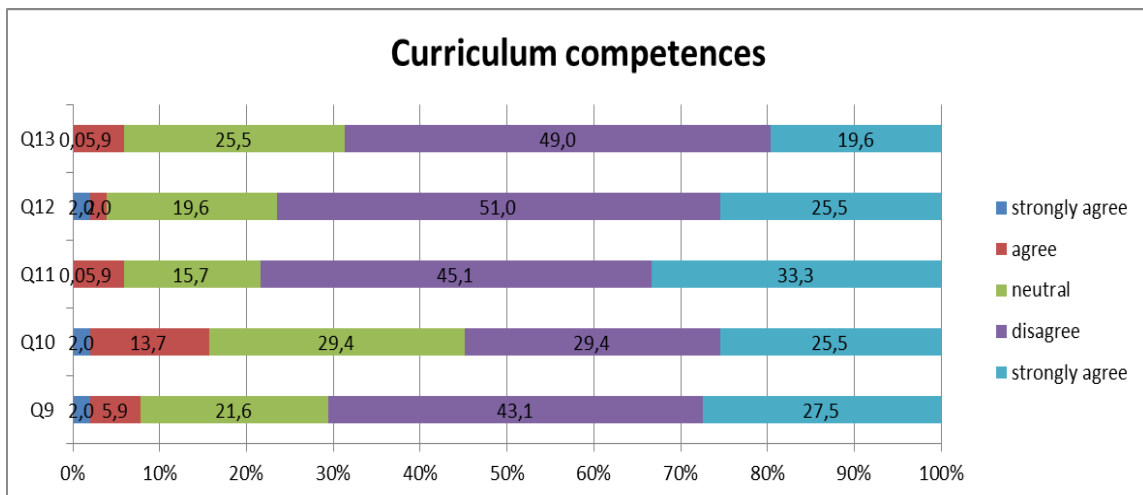


Figure 2. Student's satisfaction survey. Results from the students on the voluntary opinion survey related to the combination of PBL with traditional practical learning about curriculum competences. a) the Likert' scale score b) Likert' scale score in percentage calculated from the survey c) the summary items statistic, and d) distribution histogram (n=51).

a)

Questions	<i>Curricular competencies</i>	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
9	I better understand the subject	1	3	11	22	14
10	Awakens interest in the subject taught	1	7	15	15	13
11	I learn new knowledge	0	3	8	23	17
12	Consolidates previous knowledge	1	1	10	26	13
13	It is useful for my training as a pharmacist	0	3	13	25	10

b)



c)

Summary curricular competences Item Statistics							
	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2,871	2,627	3,059	0,431	1,164	0,026	5
Item Variances	0,837	0,668	1,158	0,490	1,734	0,040	5
Inter-Item Covariances	0,330	0,145	0,535	0,390	3,689	0,021	5
Inter-Item Correlations	0,393	0,159	0,583	0,424	3,666	0,022	5

d)

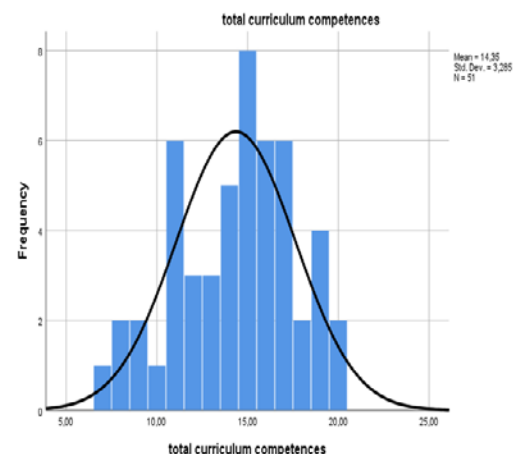
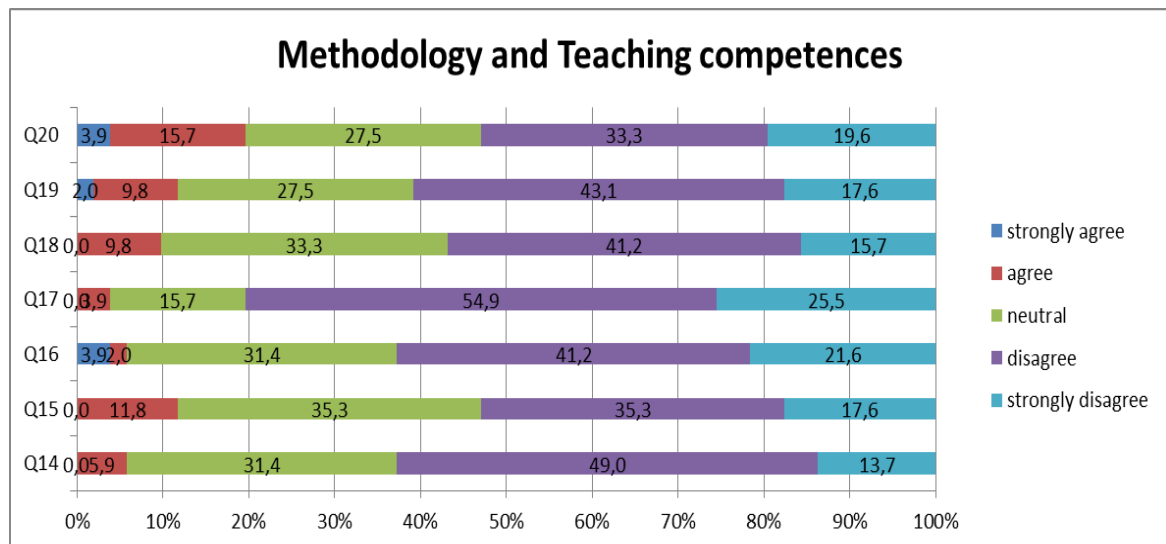


Figure 2. Student's satisfaction survey. Results from the students on the voluntary opinion survey related to the combination of PBL with traditional practical learning about curriculum competences. a) the Likert' scale score b) Likert' scale score in percentage calculated from the survey c) the summary items statistic, and d) distribution histogram (n=51).

a)

Questions	About the methodology and teaching	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)
14	Microscopic diagnostic of the ovarian dysfunction helped me to solve the posed questions asked	1	4	20	19	7
15	Uterine Cervix Cytology Diagnosis helped me to solve the posed questions asked	0	7	14	23	7
16	Hormone replacement therapy simulation helped me to solve the posed questions asked	3	7	18	17	6
17	The instructions taught by the teacher are fundamental to my learning	3	12	17	11	8
18	Teaching strategies allow me to learn from case-problem	2	5	18	16	10
19	The PBL integrated methology approach facilitates understanding of the objectives proposed	1	8	15	15	12
20	My degree of satisfaction using this methodology is	1	5	13	23	9

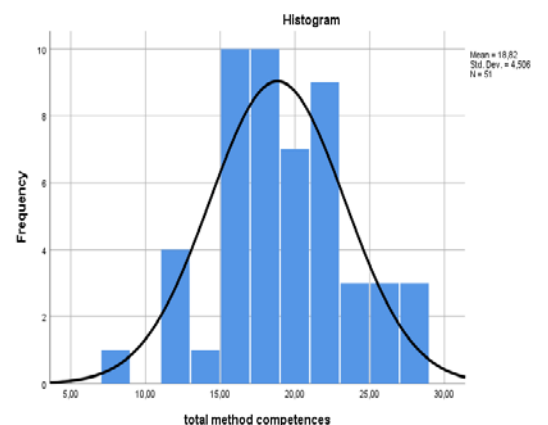
b)



c)

Summary methodology and teaching Item Statistics							
	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2,689	2,490	3,020	0,529	1,213	0,028	7
Item Variances	0,834	0,580	1,215	0,635	2,096	0,046	7
Inter-Item Covariances	0,345	0,126	0,736	0,611	5,850	0,028	7
Inter-Item Correlations	0,411	0,171	0,699	0,529	4,100	0,028	7

d)



CONCLUSIONS

The teaching methodology discussed here combines Problem Based Learning, virtual laboratories, histological study methods that lead to the resolution of the clinical case by the student and to training them as future pharmacist. The present study revealed that combined the PBL in a collaborative way with the use of computer software that simulates real physiology situations and the histologic study of structures of female reproductive system the in practical lessons of pathophysiology, favoured the learning ability of the students. PBL in the clinical environment gave students the opportunity to apply their knowledge and skills with problem and case based in real world practice. Moreover, PBL module integrated the framework of conventional teaching helped the student to integrate the knowledge of basic science subjects and to understand the important relationship between basic sciences and real clinical cases. The interaction between the designed materials for learning promoted creative and critical thinking, the acquisition of critical assessment and management skills, synthesized complex, but clinically meaningful information, debate, self-learning and feedback of the auto-learning. It was an appropriate tool for the teaching, being well accepted by the students. Their perceptions on satisfaction and usefulness of this integrated learning method toward achievement of skills which can be applied in the professional context as future pharmacist were very positive. Introduction of PBL in conventional practical lessons encouraged both the teachers and the students to experiment with a new approach to learning. We demonstrated that a combination of teaching methods encourage for effective and efficient teaching.

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COMUNICACIONES PRESENTADAS A CONGRESOS DOCENTES INTERNACIONALES

COMUNICACIÓN 1

Autores (p.o. de firma): M. Muñoz-Picos, C. Contreras, M. Hernández-Martín, C. Rodríguez-Prados, A. Sánchez, A. Agis-Torres, B. Climent, P. Recio, R. Raposo, S. Benedito, A. García-Sacristán, L. Rivera, D. Prieto, M. Hernández, M.E. López-Oliva
Título: Designing practical PBL lessons for female reproductive system physiopathology teaching.

Tipo de participación: Virtual

Congreso: ICERI19 the 12th annual International Conference of Education, Research and Innovation

Lugar de celebración: Sevilla. España.

Fecha 12-13 de noviembre, 2019.



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Special Needs Education and Inclusion	Blended and Flipped learning
Teacher Training Experiences	Massive Open Online Courses (MOOC)
Professional Development of Teachers	Videos for Learning
New Experiences for Curriculum Design	Virtual and Augmented Reality
Links between Education and Research	Social & Digital Media in Education

COMUNICACIÓN 2

Autores (p.o. de firma): C. Contreras, M. Hernández-Martín, M. Muñoz-Picos, C. Rodríguez-Prados, V.S. Fernandes, A. Agis-Torres, A. Sánchez, B. Climent, P. Recio, R. Raposo, S. Benedito, A. García-Sacristán, L. Rivera, D. Prieto, M. Hernández, M.E. López-Oliva

Título: The positive impact of practical PBL lessons on student learning in female reproductive system pathophysiology.

Tipo de participación: Virtual

Congreso: INTED20 14th annual International Technology, Education and Development Conference.

Lugar de celebración: Valencia. España.

Fecha: 2-4 de marzo de 2020.



The poster features a dark background with a central image of a modern building's interior with a large, curved, white architectural structure. The text is in white and yellow. At the bottom left, there is a QR code and the text 'Abstract submission deadline: 21st November 2019' and 'iated.org/inted'.

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Computer Supported Collaborative Work	Evaluation and assessment
MOOC's (Massive Open Online Courses)	University-Industry Cooperation
Virtual universities	Global issues in education

COMUNICACIÓN 3

Autores (p.o. de firma): V.S. Fernandes, M. Hernández-Martín, C. Contreras, M. Muñoz-Picos, C. Rodríguez-Prados, A. Agis-Torres, A. Sánchez, B. Climent, P. Recio, R. Raposo, S. Benedito, A. García-Sacristán, L. Rivera, D. Prieto, M. Hernández, M.E. López-Oliva.


Título: Effect of a novel PBL-traditional learning strategy on students' knowledge acquisition in pathophysiology. A pre-test and post-test study.

Tipo de participación: Virtual

Congreso: EDULEARN 12th annual International Conference on Education and New Learning Technologies

Lugar de celebración: Palma de Mallorca (España).

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Notification of Acceptance/Rejection	April 8th, 2020
Final Paper Submission Deadline	May 7th, 2020
Registration Deadline for Authors	May 7th, 2020

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Pedagogical Innovations in Education	Blended Learning
Professional Development of Teachers	Mobile Learning
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Flipped Learning	Social & Digital Media in Education
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E-Assessment	Educational Software & Games
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COMUNICACIÓN 4

Autores (p.o. de firma): A. Sánchez, M. Hernández-Martín, C. Rodríguez-Prados, C. Contreras, M. Muñoz-Picos, B. Climent, P. Recio, R. Raposo, S. Benedito, A. Agis-Torres, A. García-Sacristán, L. Rivera, D. Prieto, M. Hernández, M.E. López-Oliva.

Título: The potential for a new PBL integrated with simulations and laboratory diagnosis tool in pharmacy education. A questionnaire-based study

Tipo de participación: Virtual

Congreso: ICERI20 13th annual International Conference of Education, Research and Innovation

Lugar de celebración: Sevilla (España).

Fecha: 9-11 de noviembre de 2020.

