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A RESEARCH VISION

Biomedical Engineering: experiences in the research formation with MOODLE

Ingeniería Biomédica: experiencias en la formación investigativa con MOODLE

**Angel Regueiro-Gómez¹, Carmen Brígida Busoch-Morlán²,
Carmenchu Regueiro-Busoch³, René Joaquín Díaz-Martínez⁴**

Abstract

The work shows the didactic experiences reached in the research formation of biomedical engineers in the Technological University of Havana (Cujae), during the development of courses (Project of Research I and II) in the Biomedical Engineering program, that contribute to the scientific and methodological development of the Work of Diploma like act of culmination of the university studies, with the integrated employment of the resources of a Learning Management System: MOODLE (Forum, Dynamic Presentations, Videos, WIKI, Tasks,

¹ BSc. in Electronic Engineering, Instituto Superior Politécnico “José Antonio Echeverría” (Cujae), CUBA. PhD. in Electronic, UPC, Barcelona, Spain. Professor: Universidad Tecnológica de La Habana “José Antonio Echeverría” (Cujae) / Department of Bioengineering (CEBIO) / Havana, CUBA. E-mail: regueiro@automatica.cujae.edu.cu ORCID: <https://orcid.org/0000-0003-2239-1324>

² BSc. in Automatic Engineering, MSc. in Automatic, Instituto Superior Politécnico “José Antonio Echeverría” (Cujae), CUBA. Professor: Universidad Tecnológica de La Habana “José Antonio Echeverría” (Cujae) / Department of Automatic & Computation, Havana, CUBA. E-mail: cbusoch@automatica.cujae.edu.cu ORCID: <https://orcid.org/0000-0002-1290-669X>

³ BSc. in Automatic Engineering, MSc. in Automatic, Universidad Tecnológica de La Habana “José Antonio Echeverría” (Cujae), CUBA. Professor: Universidad Tecnológica de La Habana “José Antonio Echeverría” (Cujae) / Department of Automatic & Computation, Havana, CUBA. E-mail: carmenchurb@nauta.cu ORCID: <https://orcid.org/0000-0001-5101-4050>

⁴ BSc. in Electronic Engineering, Instituto Superior Politécnico “José Antonio Echeverría” (Cujae), CUBA. MSc. & PhD in Electronic, Instituto Superior Politécnico “José Antonio Echeverría” (Cujae), CUBA. Professor: Instituto Tecnológico de Monterrey, Monterrey, Mexico. E-mail: renejdm@tec.mx ORCID: <https://orcid.org/0000-0002-7440-0045>

Surveys, Questionnaires, etc.) and the Teaching Based in Problems (EBP), to achieve the appropriate motivation and research formation in the students from the curriculum.

Keywords: Biomedical Engineering, Research education, undergraduate program, LMS.

Resumen

El trabajo muestra las experiencias didácticas alcanzadas en la formación investigativa de ingenieros biomédicos en la Universidad Tecnológica de La Habana (Cujae), durante el desarrollo de la impartición semipresencial de cursos de pregrado (Proyecto de Investigación I y II), que contribuyen al desarrollo científico y metodológico del Trabajo de Diploma como acto de culminación de los estudios universitarios, con el empleo integrado de los recursos de un Sistema de Gestión del Aprendizaje: Plataforma MOODLE (Foro, Presentaciones Dinámicas, Videos, WIKI, Tareas, Encuestas, Cuestionarios, etc.) y la Enseñanza Basada en Problemas (EBP), para lograr la adecuada motivación y formación investigativa en los estudiantes desde lo curricular.

Palabras clave: Ingeniería Biomédica, Formación investigativa, Pregrado, Sistema de Gestión del Aprendizaje.

1. Introduction

Nowadays, the professional education in Engineering [1] is limited by different factors such as the mobility toward the universities, the readiness of time and the costs in the education related with the development of curricula, with a bigger essence of contents to reach certain objectives, competitions and abilities in the students, and a smaller number of present hours to achieve the professional appropriate formation [2-3].

A possible solution to this complex situation can be developed with the integrated employment of the resources of a Learning Management System (LMS), that which allows to guarantee the transmission of knowledge [4-6]. This alternative in occasions is limited by the technical

characteristics of the computer services in the university institutions (bandwidth and computation capacity) and the level of pedagogic preparation of the teachers and their experiences in the didactic appropriate employment of the means and available resources. In particular, in the undergraduate program, the flexible transmission of the knowledge constitutes one from the most complex problems to solve by teachers and students, the first with the responsibility of being better directors in the development of study methods including the formation of human values, and the seconds, as main actors of the teaching-learning process in search of better education [7-8] that includes the self-preparation. As part of the educational services development by Department of Bioengineering (CEBIO) in the School of Automatic and Biomedical Engineering at Universidad Tecnológica de La Habana (Cujae), the educational community proceeded to introduce the combined employment of a LMS (MOODLE), the ICT (Information and Communications Technologies) and the techniques of LBP (Learning Based in Problems) for the development of several courses of the Integrative Discipline: Bioengineering (Table 1), which drives the investigative education of the students from their first Research Training Practice in the middle of the curricula until the obtention of the corresponding degree as result of public sustentation of a thesis (exercise of culmination of the university studies) [9].

In these courses, numerous materials were included and diverse resources were used for the development of the participants, such as: dynamic presentations, scientific articles and patents, books, professional videos, surveys, questionnaires, forums, tasks and others (Table 2), that allowed the transmission and the exchange of experiences with more flexibility: "Any Time Any Where" [10-11], obtaining the best results in the research work and in the professional formation of the students [12-13].

Table 1. Relationship of subjects in the discipline of Bioengineering (Program of Biomedical Engineering in Cujae).

Subjects	Year	Main objective	Comments
Biomedical Engineering I	1	To characterize of the Program of Study and the university services	Annual subject developed by biweekly encounters that it includes visits to centers and institutions related with the profession and the design of biomedical technologies.
Biomedical Engineering II	2	To characterize the main devices (electric, optoelectronics and others) used in the design of biomedical technologies.	
Research Training Practice I	2	To carry out an instrumental rising in the assigned center (it includes a project for the use of energy payees) and to detect a scientific problem of the specialty.	Concentrated activity at the end of the second semester during 21 days, that it allows the association of the student with a scientific problem related with the speciality (Bioengineering)
Project of Research I	3	To carry out the bid of a research topic applying a scientific method (Waterfalls method).	The student begins with the elaboration of a contract for planning the research process and analysis the feasibility of the research project proposal.
Research Training Practice II	3	To carry out the experimental phase of the research project	Concentrated activity at the end of second semester during 21 days, that it allows the student and their tutor to develop the design of scientific experiments for the confirmation of the departure hypothesis
Project of Research II	4	To carry out the analysis of the research results (it includes economic analysis); as well as the divulgation of these in a scientific event.	The student prepares a POSTER for a scientific event, showing their research results (the best works can be sent to a scientific journal).
Thesis of Diploma Work	4	To prepare and to sustain the investigation results for the obtaining of the degree.	Development of public defense of the Thesis for the analysis of student's professional education.

Source: own.

In a Learning Management System exists other more specialized resources that facilitate the learning "On line", for example: Open-meetings: resource for the development of teleconferences, virtual encounters and/or development of individual or group evaluation (Ex.: defense of research projects). This type of resources is not always available due to limitations of bandwidth, cost and security of the computer services offered by the university institutions.

Table 2. Resources of MOODLE used in the investigative formation of Biomedical engineering in Cujae.

Resources	Equivalence in the classic teaching	Comments
Dynamic expositions	Present activities with oral expositions (Ex.: conferences, seminaries and others).	Used tools: Power Point and Video editor (Ex.: Camtasia Studio).
Database	Control book (assistance and evaluation).	It is used for the control of students' data and tutors (internal or external to the university).
BLOG	Present activities for the professional argument (Ex.: Seminars, Practical classes and others).	It is used by the participants for the presentation of reports in engineering format (IEEE) and dynamic expositions.
CHAT	Activities related with the explanation of doubts on imparted topics.	It permits the explanation (personalized or team) without barriers of time or place.
WIKI	Present activities for the professional argument (Ex.: Seminars, workshop and others).	It allows the development of group during the elaboration of specific topics, beginning from a text written by the professor.
Questionnaires, Surveys and Consultations	Activities of systematic evaluation (Questions, works of partial control and others).	It facilitates the control of the individual performance of the students so that the teacher can exercise a personalized attention.
Labels	Methodological orientation for the development of educational activities.	It facilitates the orientation of the activities to carry out for the students during the phases of their investigative preparation.
Tasks	Activities of partial evaluation (Ex.: Reports of research, seminars, workshops and others).	It facilitates the control of the individual performance of the students.

Source: own.

2. Materials and method

The tool basic employee was MOODLE (V3.2) mounted in a server developed with a cluster of two computers with good benefits and the PROMOX system that allowed to establish weekly copy, saving all contents of MOODLE and to work with complementary different virtual services: CEBIO WEB and repository (ftp site) of thesis, digital books, patents and articles of journals and congress related with the profession, avoiding the loss of information during the development of subjects.

In the preparation of different materials the basic tools of Office (WORD, EXCEL and Power Point) and a video editor (Camtasia Studio) were used, it allowed the elaboration of dynamic expositions (multimedia) in a format for their easy reproduction in the available means of the students (Table 3), such as: portable computers or of desk (personal or prepared in the calculations centers of the department and university), Tablets and the intelligent telephones of wide use in the university population. The participants were connected from any network point with national or international access to the MOODLE platform.

Table 3. Characteristic of the student sample in the group of Biomedical Engineering.

Total	Men	%	Women	%	Comments
63	33	52.3	30	47.6	The participants belong to 4 and 5 years of Biomedical Engineering (Course 2019-2020).

Source: own.

3. Implementation, results and discussion

The figure 1 shows the presentation of different courses in LMS: MOODLE-CEBIO, where the objectives and the content are declared; also, it shows the basic and complementary bibliography, and a group of methodological orientations for the students.

Figure 1. Windows of initial presentation of courses related with the research formation of the students in Biomedical engineering (Cujae).

The image displays two overlapping screenshots of a Moodle course page for 'SGA-CEBIO Departamento de BIONGENERÍA'. The top screenshot shows the 'Proyecto de Investigación I' page, which includes a calendar, navigation menu, and a search bar. The bottom screenshot shows the 'Proyecto de Investigación II' page, which features a 'General' section with the following content:

General

Bienvenidos estimados participantes.

Esperamos que Uds. puedan disponer de las prestaciones y recursos de esta plataforma SGA (MOODLE) como apoyo a la enseñanza semipresencial para flexibilizar la socialización de resultados de I+D en su respectivos temas durante el desarrollo del curso Proyecto de Investigación II, lo cual sin duda constituirá una experiencia interesante que les permitirá mejorar su proyección profesional durante la presentación de su quehacer semestral.

Sin más, mis mejores deseos de éxitos personales y profesionales.

Colectivo de Asignatura
CEBIO, CUJAE

ASIGNATURA: Proyecto de Investigación II

Objetivo básico del curso

- Aplicación de las herramientas básicas de soporte propias para el desarrollo de un método de Investigación Científica Aplicada en el área de Ingeniería Biomédica, de acuerdo a la selección del tema de investigación y bajo la dirección de un especialista (Docentes, investigadores y colaboradores).

Contenido: Los contenidos a abordar en cada Proyecto de Investigación estarán orientados por los Directores respectivos de I+D, y serán particularizados en cada caso según la temática científica seleccionada a través del debate en seminarios y foros (La forma de desarrollo de las asesorías científicas será bajo la estrategia establecida por el Dpto. y los coordinadores de las Líneas de Investigación, a la cual están vinculados los investigadores, docentes y colaboradores, con horarios flexibles que permitan el desarrollo exitoso del proceso de investigación en sus diferentes etapas, garantizando la experimentación y el desarrollo de secciones del trabajo científico asignado).

Habilidades a lograr:

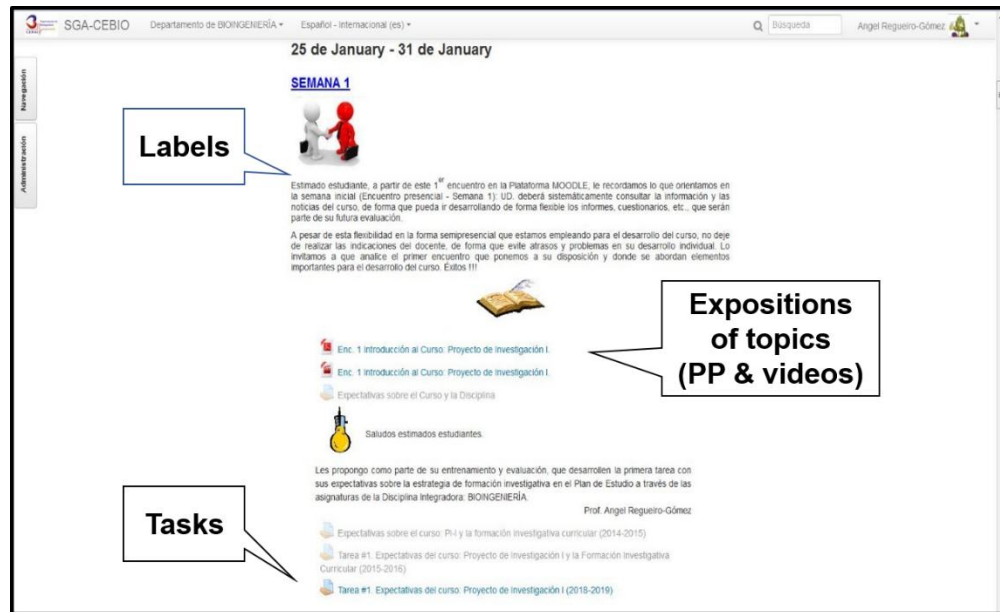
- Profundización en la proyección, planificación y aplicación de un método científico de investigación para el desarrollo de la simulación de modelos (matemáticos, mecánico-eléctricos, etc.) el diseño electrónico, y la experimentación, como soportes básicos del Proyecto I+D. Trabajo de Diploma.

The interface also includes sections for 'ENLACES DE SECCIÓN', 'ACTIVIDADES', 'ULTIMAS NOTICIAS', and 'USUARIOS EN LINEA'.

Source: own.

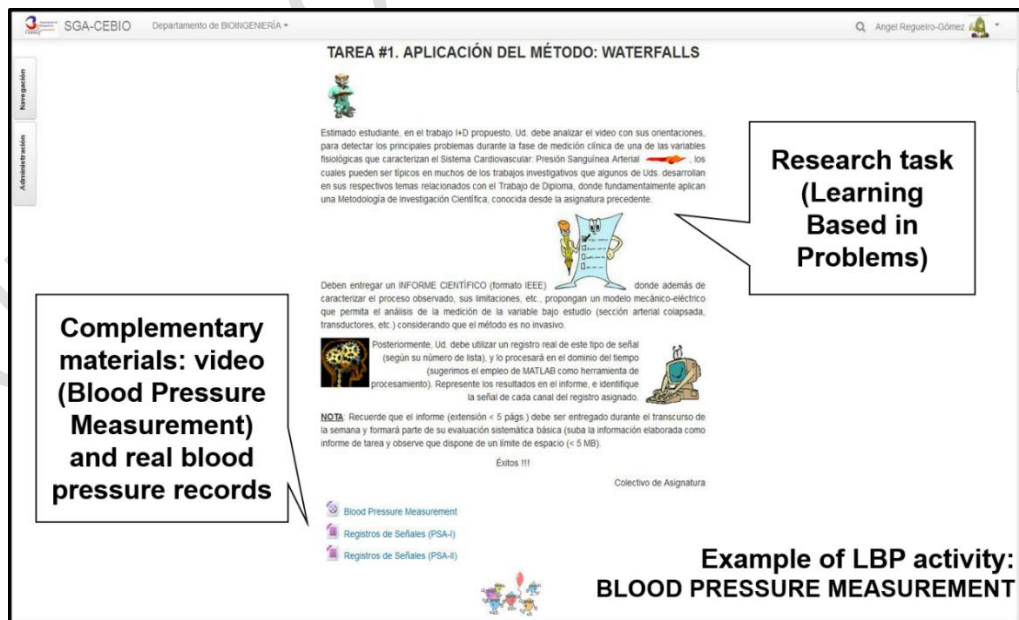
The following figures show the integrated employment of diverse resources and activities of LMS for the development of the courses, where it combine labels (Figure 2), presentations of contents in diverse formats (Power Point and videos) and research tasks (Figures 3 and 4), that increase their complexity when the learning is based on problems related with the profession. In the work is included a database (Figure 5) and another information for use of teachers and the students (Ex.: Partial reports of evaluation, announcements with the bank of scientific problems of external institutions, and others).

Figure 2. Example of resources integration for the development of the topics of the course:
Research Project I in Biomedical engineering (Cujae).



Source: own.

Figure 3. Orientation of research task (Measurement of Arterial Blood Pressure) in the course: Investigation Project II (Biomedical engineering, Cujae).



Source: own.

Figure 4. Orientation of research task (Characterization of QRS Detecting) in the course: Project of Research II (Biomedical engineering, Cujae).

Recuerden, es **aportar evidencias de los resultados alcanzados en la segunda fase de la investigación** **DISEÑO DE EXPERIMENTOS: SIMULACIÓN Y EXPERIMENTACIÓN**. El resto debe estar preparándose pues en la próxima semana debatiremos otros nuevos temas.

Labels Éxitos !!! Colectivo de Asignatura

Tarea 2. Caracterización de un DETECTOR QRS (Cardiología) **Research task (Learning Based in Problems)**

Saludos estimados estudiantes.

Una vez más pretendemos que Uds. apliquen el método de investigación científica que conocen (WATERFALLS) con ayuda de un aprendizaje basado en problemas, y para esto este cuestionario aborda una situación clásica en la caracterización de un sistema biomédico que emplea un detector de complejo QRS para ofrecer el estado diagnóstico de un paciente.

Esperamos que puedan integrar conocimientos sobre esta interesante temática. Éxitos !!!

Colectivo de asignatura

Random assignment of electrocardiography signals

Questions **Time control** **Cases of Study (ECG waves)** **Bank of ECG registers**

Source: own.

Figure 5. Employment of database for the control of the participants in the development of research topics associated to the course: Project of Research I (Cujae).

RECORDATORIO (4ta Llamada) **Labels**

Es importante que **TODOS** los estudiantes que no se han reportado en la **BASE DE DATOS**, por favor, entren y coloquen la información en los campos solicitados, pues después pueden tener dificultades al no estar registrados en la asignatura, y esto les puede influir en el resultado evaluativo de la misma, especialmente en el 1er corte (C-1) como les comenté al inicio del semestre (1era actividad presencial).

Éxitos !!!

Database (topics control)

AVISO:

En este encuentro presentamos algunos temas de I+D adicionales que nos han enviado desde el **Centro Nacional de Electromedicina (CICEM)** para el desarrollo de Trabajos de Diploma.

Por favor, los estudiantes interesados que no dispongan de un tema de investigación, y seleccionen alguna de estas nuevas propuestas, deben contactar al **Ing. Sebastian** por email y/o teléfono, y deben además actualizar los datos en la BD de control del curso cuando coordinen la tutoría de la tesis (recuerden que los trabajos son individuales).

Éxitos !!!

Proposal of new research topics

Propuesta de TEMAS para Trabajo de Diplomas (CNE)

Source: own.

In the final phase of the research formation general, some topics of professional interest are proposed, such as the protection of scientific results (Ex.: patents and registrations of products) (Figure 6 Sect. Higher Left), and the development of technical records and costs of biomedical systems (Figure 6 Sect. Higher Righth); besides using other resources like the socialization of previous research topics (Figure 6 Sec. Low Left) or the analysis of technical validation of biomedical technologies (Figure 6 Sec. Low. Right: topics are showed in English to reinforce the learning of that language in the biomedical program).

Figure 6. Examples of topics and activities developed in the courses of research formation in Biomedical engineering (Cujae).

The figure consists of four panels arranged in a 2x2 grid, each representing a different course topic and activity. Each panel includes an icon, a title, a greeting, a main text block, a closing, and a list of activities.

- Top Left Panel:** **PROTECTION OF INVENTIONS (PATENTS)**. Icon: A person at a computer. Text: "Saludos estimados estudiantes. En la fase actual en que se encuentran muchas de sus investigaciones, es necesario revisar si sus aportes son novedosos, pues quizás algunos puedan optar por la SOLICITUD de PATENTE o el REGISTRO de APLICACIÓN INFORMÁTICA (SOFTWARE). Para conocer más sobre este interesante tema sobre protección de resultados científicos, le invitamos a que analice la presentación que ponemos a su disposición y revise la información complementaria. Éxitos !!! Prof. Angel Regueiro-Gómez". Activity: "PROTECCIÓN de INVENCIÓNES (PATENTES) y REGISTROS INFORMÁTICOS (SOFTWARE)".
- Top Right Panel:** **TECHNIQUE AND COST CARDS**. Icon: A hexagon with a circuit symbol. Text: "Saludos estimado equipo de cuasi-BIOINGENIEROS !!! En esta semana les proponemos un nuevo reto a través de un interesante ejercicio que apoyará su formación profesional, pues debe permitirles sintetizar la descripción de sus resultados (parciales o totales) de investigación, y socializarlos a través de un DOCUMENTO PROMOCIONAL que contenga una FICHA TÉCNICA y una FICHA de COSTO de esos resultados según está establecido para las instituciones productoras de tecnologías biomédicas en el país. Éxitos !!! Prof. Angel Regueiro-Gómez". Activity: "TAREA #2. Desarrollo de FICHA TÉCNICA y FICHA de COSTO".
- Bottom Left Panel:** **LEARNED LESSONS**. Icon: A beach scene with a palm tree. Text: "Saludos estimados estudiantes. A partir de la revisión de los resultados del semestre anterior vinculados a la fase del diseño experimental, le proponemos que analice el material que ponemos a su disposición, con el objetivo de puntualizar algunos importantes aspectos a considerar en sus respectivos trabajos de diplomas. Esperamos que esto pueda ayudarlos a mejorar mucho más el trabajo de esta importante fase de la investigación en la cual se encuentran. Éxitos !!! Prof. Angel Regueiro-Gómez". Activity: "LECCIONES APRENDIDAS: Caso de Estudio BIOMECÁNICA".
- Bottom Right Panel:** **TECHNICAL EVALUATION OF MEDICAL EQUIPMENT**. Icon: A brain scan. Text: "A continuación, una nueva e interesante propuesta de integración de conocimientos relacionados con la Ingeniería Biomédica. Espero que nos ayuden, muchas gracias. Éxitos !!! Prof. Angel Regueiro-Gómez". Activities: "Technical Validation of Biomedical Technologies" and "Blog: Validation of Biomedical Technologies".

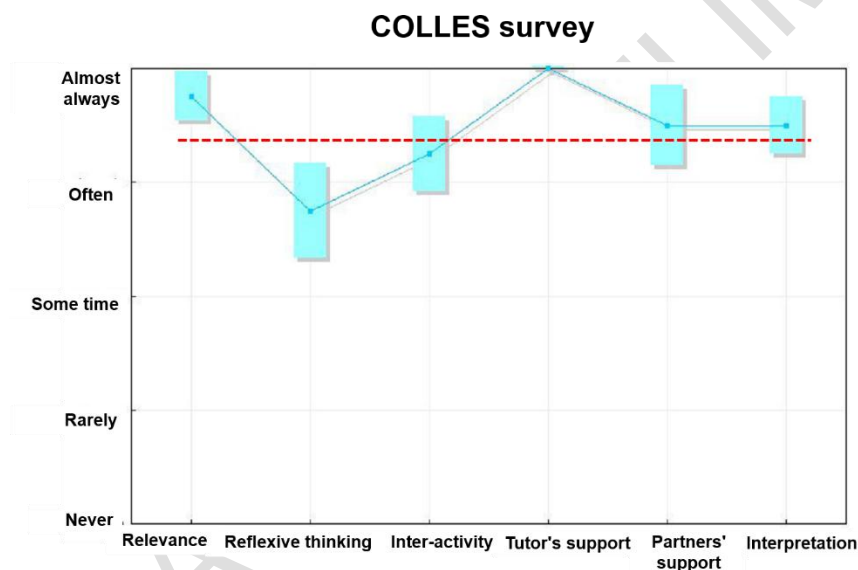
Source: own.

The BLOG was the space used in the virtual teaching for the debate and socialization of advances and results achieved by the participants in their topics throughout the courses. This space of exchange scientific-technician showed the honesty of the participants, the responsibility in the handling of scientific information, the solidarity and creativity in the

development of the assigned tasks; as well as the sense toward the institution and other ethical and juridical aspects related with the activities of the course.

The figure 7 shows the approaches received in the application of a COLLES survey. This survey was used as instrument to measure the acceptance of the employment of the virtual teaching through the resources of LMS during research formation, showing very good results in the variables evaluated by the participants.

Figure 7. Results obtained of a COLLES survey applied in the LMS (MOODLE) to the participants.



Source: own.

The survey applied shows that the process of the students' reflection was the lowest indicator, due to the new form of focus of the proposed problems related with the profession. However, in general the participants showed good satisfaction (> 93 %) in the teaching shape and the general results of the courses.

4. Conclusions

The didactic strategies used for the virtual learning in the development of the research formation in the courses, with the combined employment of LMS's resources, the ICT and the techniques

of Learning Based in Problems, has allowed a bigger flexibility in the educational process, with a bigger incidence personalized in the habits, abilities and methods of the participants, improving their academic and professional performance.

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References

- [1] Committee on Engineering Education, "Educating the Engineer of 2020: Adapting Engineering Education to New the Century", NAE, pp. 1-209, 2010. Available at: <http://www.nap.edu/catalog/11338.html>
- [2] World Health Organization, "World health statistics overview 2019: monitoring health for the SDGs, sustainable development goals", Geneva: World Health Organization; pp. 1-28, 2019.
- [3] World Health Organization, "Human resources for medical devices, the role of biomedical engineers". Geneva: World Health Organization; pp.: 1-240, 2017.
- [4] J. Sappey and S. Relf, "Digital Technology Education and its Impact on Traditional Academic Lists and Practice". J. Univ. Teach. & Lear. Pract. 7(1), 7(3), 2007.
- [5] R. Castaño Támara y R. Gordo Muskus, "La universidad del siglo XXI y la idea de tecnología, educación y comunicación", *Visión Electrónica*, vol. 12, no. 1, pp. 124-131, 2018. <https://doi.org/10.14483/22484728.14803>
- [6] H. Gómez Castillo, "TIC, convergencia y flexibilidad: saberes y racionalidades de la tecnologización pedagógica", *Visión Electrónica*, vol. 12, no. 2, pp. 319-338, 2018. <https://doi.org/10.14483/22484728.14765>
- [7] J. Candle-Valdés, "The challenges of the Cuban new university". Paper presented at the Pedagogy 2007, Havana, Cuba, pp. 1-14, feb. 2007.
- [8] K. M. Galotti, et al., "To New Way of Assessing Ways of Knowing: The Attitudes Towards Thinking and Learning Survey (ATTLS)". *Sex Lists*, 40(9/10), 745-766, 1999.
- [9] Ministerio de Educación Superior, Documento Ejecutivo Plan de Estudio: Ingeniería Biomédica, MES, La Habana, Cuba, págs. 1-10, 15 julio, 2017.
- [10] T. T. Bekele, "Motivation and Satisfaction in Internet-Supported Learning Environments: To Review". *Educ. Tech. & Soc.*, 13(2), 116-127, 2009.

- [11] S. N. Karagiannis, "The Conflicts Between Science Research and Teaching in Higher Education: An Academic's Perspective". *J. Teach. and Lear. Higher Educ.*, 21(1), 75-83, 2010.
- [12] R. Garrote and T. Pettersson. "The use of learning management systems: A Longitudinal Case Study". *Eleed*, 8. 2011.
- [13] R. Hernández-Sampier y otros, "Metodología de la Investigación. 6ta Ed., Ed. McGraw-Hill Education. México D. F., págs. 1- 634, 2014.

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