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Differential efficacy of the resources used in B-learning environments

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Abstract

Background: Learning is increasingly frequent in B-Learning spaces. It is therefore necessary to study the characteristics that guarantee deeper and more successful learning in these learning environments. **Method**: We work with sample of 233 university students using the Moodle 3.1 platform in the third year of their degrees in Health Sciences. The effectiveness of four types of B-Learning on Learning Results (LR), behaviors on the platform, and student satisfaction are all studied. Prior knowledge is also used as a covariable. **Results:** It was found that the B-Learning environment in which the students obtained better general Outcomes Learning Results (LR) and a higher degree of satisfaction was the one that included the use of infographics and virtual laboratories based on Self-Regulated Learning (SRL). **Conclusions:** The design of B-Learning environments together with the use of SRL, is a factor that enhances effective learning and increases student satisfaction, especially if they include infographics and virtual laboratories. In addition, the use of these resources implements better overall LR on a larger number of students. Likewise, it promotes more homogeneous groups in the general LO. Future investigations will be aimed at verifying these results in other knowledge branches.

Keywords: Blended learning B-learning, virtual labs, infographics, self-regulated learning (SRL), learning outcomes.

Resumen

Eficacia diferencial de los recursos empleados en entornos B-learning. **Antecedentes:** es cada vez más frecuente que el aprendizaje se realice en espacios B-Learning. Por ello, es preciso estudiar cuáles son las características que garantizan en estos entornos aprendizajes más profundos y exitosos. **Método:** se trabajó en la plataforma Moodle 3.1 con una muestra 233 estudiantes universitarios de tercero de grado en la rama de Ciencias de la Salud. Se estudió la efectividad de cuatro tipos de B-Learning sobre los Resultados de Aprendizaje (RA), las conductas de aprendizaje y la satisfacción de los estudiantes. Asimismo, se utilizó como covariable los conocimientos previos. **Resultados:** se halló que el entorno B-Learning en el que los estudiantes obtuvieron mejores RA generales y mayor grado de satisfacción fue el que incluía el uso de infografías y de laboratorios virtuales basados en aprendizaje autorregulado (SRL). **Conclusiones:** el diseño de entornos B-Learning, junto con la utilización de SRL, es un factor que potencia aprendizajes eficaces e incrementa la satisfacción de los estudiantes, especialmente si incluyen infografías y laboratorios virtuales. Además, el uso de estos recursos implementa mejores RA generales en un mayor número de estudiantes. Futuras investigaciones irán dirigidas a comprobar estos resultados en otras ramas de conocimiento.

Palabras clave: blended learning (B-learning), laboratorios virtuales, infografías, aprendizaje autorregulado, resultados de aprendizaje.

Over recent decades, the use of Blended Learning (B-Learning) environments is increasingly frequent in both state-regulated and non-regulated education. These environments are managed with Learning Management System (LMS). Both imply an important challenge in the research of learning processes. Among others, we may highlight the studies of Azevedo (2014) on Self-Regulated Learning (SRL) that are based on the theoretical work of Zimmerman & Moylan (2009) applied to hypermedia learning environments. In particular, Taub & Azevedo (2019) found significant differences among student users of the LMS in the application of cognitive and metacognitive skills, taking account of the level of previously acquired knowledge. The students with high levels used more complex cognitive and metacognitive skills for its resolution. These results are essential for the design of personalized systems of intelligent tutoring.

Thus, the design of an LMS can be diverse and can include different resources that are to do with strengthening the quality of learning (Margulieux, McCracken, & Catrambone, 2016). These resources mean that multi-channel information can be gathered, which will facilitate the study of the traceability of cognitive, affective and metacognitive skills (Azevedo et al., 2013). These learning spaces also make the analysis of SRL processes possible for both individuals and collectives. The advantage of these spaces is that they provide the teacher will a lot of information through different registries (eye-tracking, thinking aloud, note taking and drawing, log-files, and facial recognition, among others). This field of investigation is known as Advanced Learning Technologies (ALTs). Learning spaces in the 21st century therefore have to include technological resources that encourage the development of SRL, metacognitive instruction, and monitoring. One of the most effective tools is MetaTutoring (Azevedo et al., 2013) that can be implemented through different hypermedia resources (quizzes with automated feedback, virtual laboratories, infographs, etc.). They all

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have the purpose of providing feedback to the learner for problem-solving tasks that help monitoring: focalization of the object of the task, activation of previous knowledge, searching for strategies to resolve the problem, evaluation throughout the problem-solving process, changes if needed to the problem-solving strategy, and final evaluation (Taub & Azevedo, 2019). Those resources respect the learning pace of the student, facilitating personalization (Sáiz, García-Osorio, Díez-Pastor, & Martín, 2019).

From among all the possible registers, it is worth highlighting the behavioral patterns in the learning process. Among them, information can be obtained on: frequency of access of the student to the platform and the use of resources (Cerezo, Sánchez-Santillán, Paule-Ruiz, & Núñez, 2016).

Likewise, recent studies (Sáiz, Marticorena, García-Osorio, & Díez-Pastor, 2017) have pointed to a greater effectiveness of B-Learning spaces in which 80% of the teaching is done in virtual environments and 20% is done Face to Face (F2F). Along these lines, other researchers have indicated that the effectiveness of these spaces will increase, if they include hypermedia resources (videos, quizzes, forums…) (Cerezo et al., 2016) and active methodologies such as Project-Based Learning. (PBL) (Bannert, Reimann, & Sonnenberg, 2014). With regard to the hypermedia resources, among the most novel is the use of infographs. These graphs display information and can include: words, phrases, images, and videos. If they include images and interactive resources they can be especially effective. It seems that they facilitate dynamic conceptual understanding of the subject matter among students (Al-Dairy & Al-Rabaani, 2017). In addition, they increase the motivation and the creativity of the students (Damman, Vonk, van den Haak, van Hooijdonk, & Timmermans, 2018; Papic & Sušilović, 2018). In summary, the infograph is considered a low-cost resource that improves conceptual understanding and retention (Kiernan, Oppezzo, Resnicow, & Alexander, 2018; Nogueira-Frazão & Martínez-Solana, 2019) and problem-solving (Santos, Pereira-Neto, & Neves, 2019). In addition, this resource facilitates the development of SRL and reflection on the contents under study (Balkac & Ergun, 2018). It has likewise been demonstrated that the infograph increases its effectiveness, if it contains questions for SRL (Haşlaman, 2018; Santos et al., 2019). Along these lines, this resource is administered to achieve personalized learning among the students (Gutiérrez, Barriga, Ramírez-Corona, López-Malo, & Palou, 2016).

Another novel hypermedia resource in B-Learning spaces, is the use of virtual laboratories. Alves et al. (2016) and Viegas et al. (2018) affirmed that their implementation can improve teaching in a virtual as well as a presential mode. The virtual laboratory has especially been applied as a resource in the disciplines of Engineering and the Health Sciences. The advantages of its use are the personalization of teaching and cost reductions (Viegas et al., 2018). This tool strengthens reflexive learning based on the use of metacognitive skills and SRL (Achuthan, Francis, & Diwakar, 2017). In addition, the virtual laboratory has shown itself to be more effective that the presential laboratory (Koretsky, Kelly, & Gummer, 2011). The reasons are centered on the improvement of conceptual understanding with this tool, increased SRL, and the use of metacognitive skills. It all increases student motivation, satisfaction, and performance (Viegas et al., 2018). However, the weak point of this resource is excessive individuality in the learning process. Authors such as Gustavsson et al. (2009) therefore advise combining its use with collaborative actions such as PBL.

In summary, the use of infographs and virtual laboratories in B-Learning spaces appears to increase the personalization of learning and to strengthen SRL in real time (Krum, 2014; Kunze, & Rutherford, 2018; Harley, Taub, Azevedo, & Bouchet, 2018). In addition, personalization increases learning results and student interaction with the platform (Sáiz, Marticorena, Díez-Pastor, & García-Osorio, 2019).

Equally, the emergence of this type of resource, with increasingly greater celerity, makes it necessary to evaluate its effectiveness in the learning process, in the light of different quality standards: metacognitive design, technological knowledge and content (Vongkulluksn, Xie, & Bowman, 2018). In turn, each one of them contains a series of sub-standards that are described in Table 1.

Xie, Di Tosto, Chen, & Vongkulluksn (2018), in a meta-analysis on the quality of teaching in different B-Learning environments found high correlations between the evaluation of teaching materials and metacognitive structure in their design. Moreover, they found lower correlations between the valuation of the materials and the technological structure, for their implementation on the platform. These results point to the importance of using friendly interfaces (Sáiz, Cuesta, Alegre, & Peñacoba, 2017). Furthermore, different researchers (Cerezo, Bernardo, Esteban, Sánchez, & Tuero, 2017) pointed out that the use of SRL in university environments increases student satisfaction with the teaching. Moreover, as previously mentioned, the LMS includes tools that register the interactions with the different agents involved in the teaching. Nevertheless, the majority of these environments include no tools for the analysis of these data (Xie, Kim, Cheng, & Luthy, 2017) making the inclusion of plugins necessary (Luna, Castro, & Romero, 2016).

In view of the studies referred to above, which place emphasis on the rapid incorporation of technological resources at the service of learning in B-Learning spaces, especially in the teaching of Higher Education, it appears relevant to evaluate their effectiveness in real educational environments (Wiley, Bliss, & McEwen, 2014). In particular, the effectiveness of different B-Learning designs is examined in this work that implement different learning

Table 1
Standards of quality in the evaluation of hypermedia resources adapted from Xie, Di Tosto, Chen, & Vongkulluksn (2018) p. 95

Quality standards of materials	Sub-standards
Metacognitive design	Adjustment of proposed activities Well-developed monitoring Feedback throughout the process Inquiry-based activities Scaffolding Depth of learning is well developed
Well-worked content	Clarity of objectives Conceptual progression Differentiation between concepts Adaptation of the level worked in the presentation of the concepts The development of critical thought
Technological structure	Personalization User-friendliness Channels of communication Interactivity

resources, prepared with different technological tools (infographs, virtual laboratories, videos, quizzes, process-oriented automatic feedback, and PBL) applied in different combinations.

The research questions were as follows:

RQ1 Are there significant differences in student learning results in different B-Learning environments?

RQ2 Are there significant differences in student learning behaviors in different B-Learning environments?

RQ3 Are there significant differences in student satisfaction in the different B-Learning environments?

Method

Participants

The study had a sample of 233 students from the third year of degree courses in Health Sciences (see Table 2) in two subjects: subject 1 (Group 1 and Group 3) and subject 2 (Group 2 and Group 4). Teaching was imparted by the same teacher, an expert in virtual teaching, to all four groups.

The criteria for the inclusion of the student in the study was systematic participation in the course work with an acceptable presential and/or virtual participation of 85% to 100%. The exclusion criteria were non-systematic participation on the course (less than 80%). The assignation of the groups was done using convenience sampling in accordance with the possibilities of intervention. In Table 3, the characteristics of each group can be seen, as described in the section on procedure. Likewise, the logs in each of the groups were: Group 1 = 4064, Group 2 = 4982, Group 3 = 10111, and Group 4 = 13433.

Table 2
Descriptive statistics in the different groups under study with respect to the independent variables assigned to gender and age

Group	N	PK	Men			Women		
			n	M_{age}	SD_{age}	*N*	M_{age}	SD_{age}
1	58	2.68	9	24.67	4.12	49	23.82	5.10
2	63	2.00	7	22.00	1.73	56	24.02	4.98
3	55	2.40	6	22.00	1.55	49	22.53	2.34
4	57	2.39	8	24.63	7.50	49	22.33	1.96

Note: PK = Previous knowledge; Group 1 = B-Learning [20 (BL)-80% (F2F)] methodology; Group 2 = B-Learning [80 (BL)-20% (F2F)] methodology + videos + quizzes + product-oriented feedback; Group 3 = B-Learning [80 (BL)-20% (F2F)] methodology + videos + quizzes + process-oriented feedback + infographs + virtual laboratory; Group 4 = B-Learning [80 (BL)-20% (F2F)] methodology + videos + quizzes + process-oriented feedback; M_{age} = Mean Age; SD_{age} = Standard Deviation Age

Instruments

- Learning Strategies Scale (ACRAr) by Román and Poggioli (2013*)*. In this study the Scale of Metacognitive Skills was applied. It has an inter-judge reliability of $\alpha = .90$, a content validity of $r = .88$, and a construct validity of $r = .88$. In this study, the value found was $\alpha = .70$.
- Questionnaire: on previous knowledge prepared *ad hoc* with 8 questions measured on a Likert-type scale of 1 to 5 on the key concepts of the subjects. In subject 1, (Groups 1 and 3) achieved a reliability index of $\alpha = .89$ and in subject 2 (Groups 2 and 4) of $\alpha = .91$.
- Learning Management System (LMS). In this study a Moodle v.3.1 -based LMS was used. Different hypermedia resources were included (videos, quizzes, infographs, and simulation laboratory) in different combinations as a function of the groups under study, see section on procedure. Likewise, logs were analyzed on the following indicators of behavior on the platform: 1. Access to complementary information; 2. Access to guidelines to carry out PBL; 3. Access to information on theoretical content; 4. Access to feedback from the teacher; 5. Mean number of visits per day.
- Teaching support videos: prepared *ad hoc* and published in the Institutional Repository of University of Burgos (Sáiz, 2018a, 2018b). In Group 2 and in Group 3, two videos were used on the contents of the study units in which self-regulation strategies were used, by the teacher, to guide conceptual comprehension, and inter-relations. Likewise, after the presentation of each concept, a comprehension quizz was administered with feedback on the responses.

  The two videos used in Group 4 treated the content of the study unit, which included self-regulation strategies. In this case the comprehension (quizz) questions were done after watching the video and included process-oriented feedback (the reason for the correct response was indicated) on the responses from the students.

Table 3
Description of the groups under study

Resources	Group 1	Group 2	Group 3	Group 4
Use of the virtual platform (LMS)	20%	80%	80%	80%
Use of videos with product-oriented quizzes on the virtual platform (LMS)	No	Yes	No	No
Use of videos on the virtual platform (LMS)	No	No	Yes	Yes
Use of quizzes on paper	Yes	No	No	No
Use of process-oriented comprehension quizzes on the virtual platform (LMS)	No	No	No	Yes
Use of a virtual laboratory through the virtual platform (LMS)	No	No	Yes	No
Use of infographs on the virtual platform (LMS)	No	No	Yes	No
Use of quizzes for the evaluation of conceptual content with product-oriented feedback on the virtual platform (LMS)	No	Yes	No	No
Use of quizzes for the evaluation of conceptual content with process-oriented feedback on the virtual platform (LMS)	No	No	Yes	Yes

Note: PBL methodology was applied in all groups

- Quizzes: in the four groups under study, evaluation questionnaires on the contents of the quizz format were used. The multiple-choice test-type questions offered four possible responses and only one true option. The quizzes were administered at the end of each thematic unit. In Table 4, the different options may be seen that were applicable to the groups in the study (see Figure 1 and Figure 2).
- Infographics: prepared with free Piktochart software, a resource used only in Group 3. The structure of the infograph consisted in the presentation of key thematic concepts through images. Then, self-regulation questions, which guided the responses through key images, were included on the concepts that had been seen. Subsequently, the question was asked "are you clear about those concepts". If the response was negative, the question was asked "which are you not clear about?" The infographs are published under open access and held in the Repository of University of Burgos (Sáiz, 2018c, 2018d, 2018e).

Table 4
Options for the administration of the evaluation questionnaires in the groups under study

Group			Group 1	Group 2	Group 3	Group 4
Form of administration	On paper		X	–	–	–
	On the LMS		–	X	X	X
Type of feedback to the response	Product-oriented (right-wrong)		X	–	–	–
	Product- oriented (right-wrong)	(see example in Figure 1)	–	X	–	–
	Process-oriented (correct-incorrect and orientation on the reason why)	(see example in Figure 2)	–	–	X	X
Response time of the results	One week		X	–	–	–
	Immediate at the end of the questionnaire		–	X	X	X

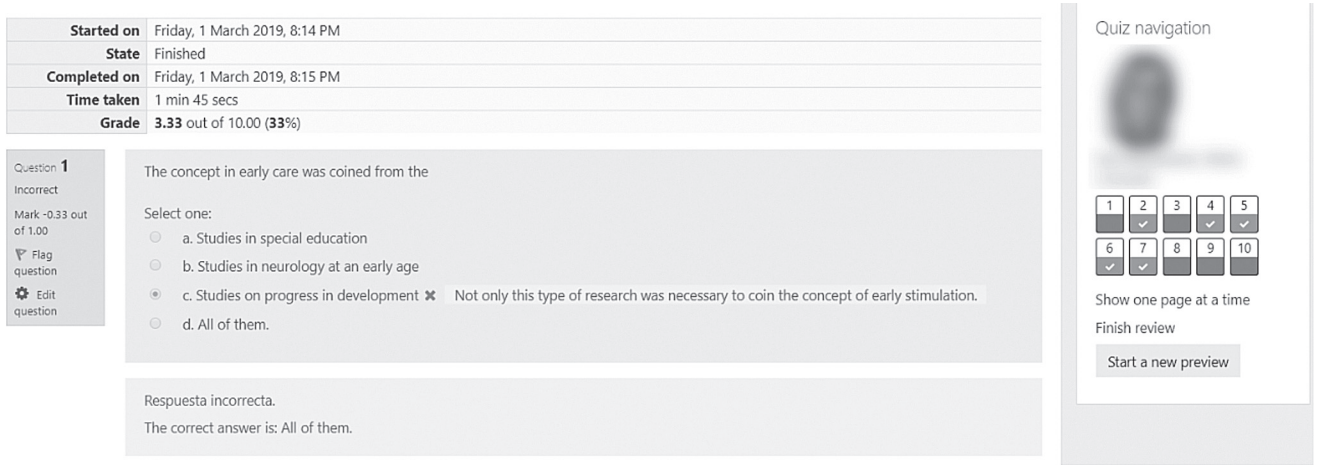

Figure 1. Quizz with product-oriented feedback administered to groups 1 and 2

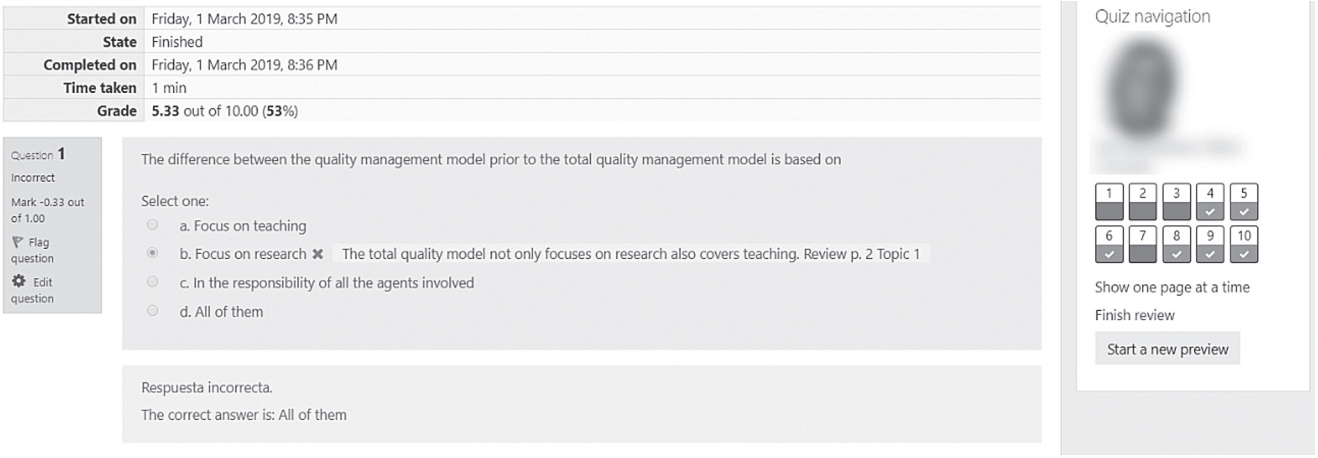

Figure 2. Quizz with process-oriented feedback administered to groups 3 and 4

- Virtual laboratories: use was made of two virtual laboratories designed from a simulation structure that provided the student with help in the form of a guide to prepare the project (PBL). Those laboratories were structured around SRL and the teacher guided the different practices by applying modeling techniques and self-instructions for solving the tasks. The steps for solving the task were recorded on video. The student could access this resource over the platform, whenever needed.
- Learning results: the learning results from different tests were considered: Preparation of the PBL, Defense of the PBL, Quizzes, and Learning Results, Totals.
- Scale of satisfaction with teaching activity. This instrument, based on the work of Marsh (1987), called Student Evaluation of Educational Quality (SEEQ) was adapted by Bol, Sáiz, & Pérez (2013). Their scale contains five clusters for the analysis of teaching quality: materials, continuous evaluation, motivation of the teacher, course workload, and the degree of general satisfaction. It has a general index of reliability of α = .92. Likewise, the one found for this study was α = .86.

Procedure

A multi-group design was used with pre-treatment measures (equaling the metacognitive skills of the group), and subsequently in the learning results, learning behavior, and student satisfaction, considering the previous knowledge as a co-variable, in order to control the perceived difficulty.

In Group 1, a B-Learning (20% in el LMS and 80% F2F) teaching methodology was used, without hypermedia resources and the quizzes were done on paper, see section on instruments.

In Group 2, a B-Learning (80% on LMS and 20% F2F) teaching methodology was applied. In addition, the group included hypermedia resources:

a. Videos on the contents of the subject matter that included quizzes, the responses to which received product-oriented feedback.
b. Quizzes for the evaluation of the contents, which were done on the LMS with process-oriented feedback: see instruments section.

In Group 3, a B-Learning teaching (80% LMS and 20% F2F) methodology was administered and the following hypermedia resources were included:

a. Videos on the contents of the subject matter that included quizzes after treating each concept, similar to those applied to Group 2.
b. Quizzes for the evaluation of the contents, which were done on the LMS with process-oriented feedback; see instruments section.
c. A virtual *ad hoc* laboratory; see instruments section. This material was made available to the students from the third week of the semester.
d. Infographs: previously described.

In Group 4, a B-Learning teaching (80% LMS and 20% F2F) methodology was administered and the following hypermedia resources were used:

1. Videos prepared *ad hoc*, without questions and quizzes in the video. However, the student after watching the video could complete a comprehension quizz-type questionnaire that could be repeated as many times as desired.
2. Quizzes for the evaluation of the contents, which were done on the LMS with process-oriented feedback, described earlier.

Data analysis

Before starting the study, the homogeneity of the groups under the variable 'use of metacognitive skills' was analyzed. A fixed-effects ANOVA (type of group) was applied to test the variable metacognitive skills measured on the ACRA Scale of Metacognitive Skills ACRA, $F_{(3,\ 233)} = 1.251$, $p = .292$, $\eta^2 = 0.02$. It was also studied whether differences existed at the level of previous knowledge of the students, for which purpose a fixed-effects ANOVA (type of group) was completed. In this case, significant differences were found between the groups, $F_{(3,\ 229)} = 14.13$, $p = .00$, $\eta^2 = 0.16$, due to which this variable was considered a co-variable. The research questions were tested with ANCOVAS. All these analyses were done on the statistical software package SPSS v.24, applying a confidence interval of 95%.

Results

A fixed-effects ANCOVA (type of B-Learning) was applied to test RQ1 on the different learning results (PBL preparation, PBL defense, Quizzes, and Learning Results (LR) totals). Significant differences were found in all the LR and the effect values were measured, following the classification of Cohen (Kelley & Preacher, 2012), in the LR for the quizzes ($\eta^2 = 0.45$), in the LR on the preparation of the PBL ($\eta^2 = 0.31$), and in the LR Totals ($\eta^2 = 0.20$). Likewise, the differences in the Bonferroni test were found for all the groups except in the LR, in the defense of PBL, and between Groups 3 and 4 in the LR on the quizzes (see Table 5). However, the covariable previous knowledge had effects of the LR Quizzes, $F_{(1,\ 228)} = 67.24$, $p = .000$, $\eta^2 = 0.47$ and not on the other results [LR preparation of PBL $F_{(1,\ 228)} = 0.38$, $p = .54$, $\eta^2 = 0.002$); LR defense of PBL, $F_{(1,\ 228)} = 0.19$, $p = .661$, $\eta^2 = 0.001$; LR Total, $F_{(1,\ 228)} = 2.38$, $p = .124$, $\eta^2 = 0.01$)].

With respect to RQ2, differences were found between all the groups, in all learning behaviors on the platform, except in access to information on theoretical content. The differences in the Bonferroni test results for groups 4, 3, 2, and 1 were found in hierarchical order from greater to lesser. With regard to access to guidelines to conduct PBL, the differences were found in Group 3 on the others in favor of this one (see Table 6). In relation to the covariable previous knowledge, it no had no effect on any of the learning behaviors in this analysis (Access to complementary information $F_{(1,\ 228)} = 0.60$, $p = .44$, $\eta^2 = 0.003$; Access to the Guidelines for PBL $F_{(1,\ 228)} = 0.81$, $p = .37$, $\eta^2 = 0.004$; Access to information on theoretical content $F_{(1,\ 228)} = 1.01$, $p = .32$, $\eta^2 = 0.004$; Access to teacher feedback, $F_{(1,\ 228)} = 0.46$, $p = .50$, $\eta^2 = 0.002$; Mean number of visits per day, $F_{(1,\ 228)} = 1.61$, $p = .21$, $\eta^2 = 0.01$.

Subsequently, a fixed-effects ANCOVA (type of B-Learning) was applied to test RQ3, finding significant differences between all the groups and under all the indicators of satisfaction with teachers, except for the motivation of the teacher towards the subject in which differences were only found between Groups 1 and 4. The highest measurements under satisfaction were found in Group 3, a group in which infographs and virtual library resources

were administered (see Table 7). In this case, the co-variable previous knowledge had no effects on any of the variables, Subject matter $F_{(1, 184)} = 0.13$, $p = .72$, $\eta^2 = 0.001$; Continuous evaluation $F_{(1, 184)} = 0.39$, $p = .53$, $\eta^2 = 0.002$; Teacher motivation $F_{(1, 184)} = 0.02$, $p = .88$, $\eta^2 = 0.000$; Workload $F_{(1, 184)} = 3.78$, $p = .05$, $\eta^2 = 0.02$; General satisfaction, $F_{(1, 184)} = 0.18$, $p = .67$, $\eta^2 = 0.001$.

Table 5
Single factor fixed-effects ANOVA (Type of group) and value of the effect and test of mean differences between the Bonferroni groups for the variable learning results

LR	Group 1 n = 58		Group 2 n = 63		Group 3 n = 55		Group 4 n = 57		Single-factor ANOVA (type of B-Learning)				Bonferroni by group
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*df*	*F*	*p*	η^2	
LR preparation of PBL (Maximum score 2.50)	2.22	.18	2.19	.42	2.40	.37	2.72	.24	3,228	33.60	.000*	0.31	-.18* 1,3 -50* 1,4 -.21* 2,3 -.53* 2,4 -.32* 3,4
LR defense of the PBL (Maximum score 2.50)	1.73	.29	1.76	.18	1.73	.18	1.64	.15	3,228	3.54	.015*	0.04	.12* 2,4
LR Quizzes (Maximum score 3)	2.15	.42	2.59	.21	2.71	.14	2.72	.15	3,228	62.66	.000*	0.45	-.44* 1,2 -.56* 1,3 -.57* 1,4 -.12* 2,3 -.13* 2,4
LR Total (Maximum score 10)	8.60	.72	9.05	.43	9.09	.49	8.15	1.15	3,228	19.95	.000*	0.21	-.45* 1,2 -.49* 1,3 .45* 1,4 .90* 2,4 .94* 3,4

* $p < .05$ Note. LR = Learning Results; *M* = Mean; *SD* = Standard Deviation; $_{df}$ = degrees of freedom; η^2 = eta squared. Group 1 = Methodology B-Learning [20 (BL)-80% (F2F)]; Group 2 = Methodology B-Learning [80 (BL)-20% (F2F)] + videos+ quizzes + product-oriented feedback; Group 3 = Methodology B-Learning [80 (BL)-20% (F2F)] + videos + quizzes + process-oriented feedback + infographs + virtual laboratory; Group 4 = B-Learning [80 (BL)-20% (F2F)] methodology + videos + quizzes+ process-oriented feedback

Table 6
Single factor fixed-effects ANOVA (Type of group) and effect value and test of intergroup different of means of Bonferroni in the variables learning behavior on the LMS

Access	Group 1 n = 58		Group 2 n = 63		Group 3 n = 55		Group 4 n = 57		Single-factor ANOVA (type of B-Learning)				Bonferroni by group
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*df*	*F*	*p*	η^2	
Access to complementary	5.07	4.60	5.87	5.49	11.38	6.34	36.46	23.82	3,229	78.00	.00*	0.51	-31.39* 1,4 -30.58 2,4 -25.07 3,4
Access to orientations to be done on the PBL	3.60	3.00	3.94	3.18	9.27	7.51	5.61	7.10	3,229	12.47	.00*	0.14	-5.67* 1,3 -5.34* 2,3 3.66* 3,4
Access to information on theoretical content	13.81	7.49	13.64	7.35	14.56	10.83	14.63	8.12	3,229	.21	.89	0.003	
Access to teacher feedback	18.43	21.14	25.44	33.18	90.47	28.40	114.28	46.13	3,229	117.37	.00*	0.61	-72.04* 1,3 -95.85* 1,4 -65.03* 2,3 -88.84* 2,4 -23.81* 3,4
Mean visits per day	1.08	.58	3.04	1.02	8.20	3.08	7.90	3.25	3,229	139.55	.00*	0.65	-1.96 1,2 -7.12 1,3 -6.82 1,4 -1.96 2,1 -5.16 2,3 -4.86 2,4

* $p < .01$ Note. *M* = Mean; *SD* = Standard Deviation; $_{df}$ = degrees of freedom; η^2 = eta squared. Note. Group 1 = B-Learning [20 (BL)-80% (F2F)] methodology; Group 2 = B-Learning [80 (BL)-20% (F2F)] methodology + videos+ quizzes + product-oriented feedback; Group 3 = B-Learning [80 (BL)-20% (F2F)] methodology + videos + quizzes + process-oriented feedback + infographs + virtual laboratory; Group 4 = B-Learning [80 (BL)-20% (F2F)] methodology + videos + quizzes+ process-oriented feedback

Table 7
Indicators of Student Satisfaction with the quality of teaching [Bol et al. (2013) adapted from Marsh (1987)]

Satisfaction	Group 1 n = 31 Response rate 53.44		Group 2 n = 51 Response rate 80.95		Group 3 n = 53 Response rate 96.36		Group 4 n = 54 Response rate 94.74		Single-factor ANOVA (type of B-Learning)				Bonferroni by group
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*df*	*F*	*p*	η^2	
Materials	4.11	.74	4.29	.64	4.56	.53	3.79	.89	3,185	10.82	.00*	0.15	-.44* [1,3] .50 [2,4] .77 [3,4]
Continuous evaluation	3.79	.93	4.23	.75	4.55	.64	3.46	.97	3,185	17.25	.00*	0.22	-.76* [1,3] -.76* [2,4] 1.08* [3,4]
Motivation of teacher	4.37	.75	4.40	.68	4.64	.40	3.75	.93	3,185	14.87	.00*	0.19	.62* [1,4] .65* [2,4] .88* [3,4]
Workload	4.23	.80	3.84	.67	4.02	.82	3.65	.93	3,185	3.81	.01*	0.06	-.58* [1,4]
General satisfaction	4.13	.67	4.31	.55	4.58	.42	3.69	.82	3,185	18.90	.00*	0.24	-.46* [1,3] .44* [1,4] .62* [2,4] .89* [3,4]

* p <.01 Note. *M* = Mean; *SD* = Standard Deviation; $_{df}$ = degrees of freedom; η^2 = eta squared

Discussion

It appears that the covariable previous knowledge influenced the learning results outcomes, particularly in the areas related with the completion of individual tasks, but not for collaborative tasks. Likewise, no incidents were observed in accessing the different LMS resources, nor in satisfaction with the teaching activity. The first results coincided with those found by Taub & Azevedo (2019). This conclusion is relevant to the design of activities in the LMS. For example, collaborative tasks could be proposed between the students in such a way that those with a higher level of previous knowledge support the work of students with lower levels. In addition, the Meta-Tutoring from the implementation of different hyper-media resources appeared to compensate the effect of the variable previous knowledge on the LR.

It was also found that the differences in the LR were not homogeneous between the different evaluation procedures. For example, better LR results were found in the preparation of the PBL in Group 4, in which a B-Learning (80%/20%) methodology was implemented with hypermedia resources of video displays and post-video comprehension quizzes. However, for the Defense of PBL, the best results were found in Group 2, in which a B-Learning (80%-20%) methodology was applied, which included videos with quizzes and process-oriented feedback. The patterns of access were greater in groups 3 and 4, which implemented the B-Learning (80%-20%) methodology with more sophisticated hypermedia resources. To do so, it appears that the B-Learning (80%-20%) design with more complex hypermedia resources increased the activity of the students on the LMS. In addition, if this environment included infographs and virtual laboratories, there was a general increase in LR (Alves et al., 2016; Cerezo et al., 2016; Gustavsson et al., 2009; Margulieux et al., 2016; Sáiz et al., 2017; Viegas et al., 2018). One possible explanation is that the combination of these resources strengthens the conceptual comprehension of the student (Al-Dairy & Al-Rabaani, 2017) and the personalization of learning (Kunze & Rutherford, 2018; Harley et al., 2018), which facilitate the SRL and foreseeably the use of metacognitive skills. All of which finally increase student motivation (Zimmerman & Moylan, 2009).

Moreover, greater satisfaction was found with the teaching activity in Group 3 which included the use of infographs and virtual laboratories; a result that is agreement with those of Achuthan et al. (2017), Haşlaman (2018), and Santos et al. (2019).

In summary, it appears that the design of the B-Learning spaces influences the LR and behavioral-learning patterns in the students. However, there are other variables, such as previous knowledge that could be exerting some influence (Xi et al., 2018), especially on the LR.

Nevertheless, the generalization of the results of this study must be treated with prudence, attending to the characteristics of the sample: number, origin, sampling, history of student learning, specificity of qualification and subject matter. Future investigations will be directed towards establishing the efficacy of B-Learning (80%-20%) environments in other areas of knowledge, in which different hypermedia resources are included.

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