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Comparison of the Effect of Two Hybrid Models of Problem-Based Learning Implementation on the Development of Transversal and Research Skills and the Learning Experience

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Problem-based learning (PBL) provides an encouraging learning environment to develop transversal and research thinking skills. However, how PBL is implemented into a curriculum can be critical for achieving these outcomes. This study compares two hybrid PBL implementation models applied in a health sciences school: a PBL-module integrated into the subjects of a traditional curriculum and full interdisciplinary PBL-courses. 651 students were involved, with 330 taking the PBL-module and 277 taking the PBL-courses. Students' and tutors' perceptions about the acquisition of the skills as well as their satisfaction with the learning experience were compared. The results showed that in the interdisciplinary PBL-courses, both students and tutors perceived a significantly higher acquisition of these skills. In addition, they also find the methodology more useful and are more satisfied with the learning experience than in the PBL-modules. A strong correlation was also observed between the acquisition of transversal and research skills and the perceived usefulness of PBL and overall satisfaction with the experience. This study provides new evidence on the characteristics of PBL that favor the development of these skills.

Keywords: problem-based learning (PBL), transversal skills, research skills, implementation, students' satisfaction

INTRODUCTION

The impact of social and cultural factors and peer interactions on cognitive development has been recognized and suggests that learning takes place through active participation in purposeful and collaborative activities (Piaget, 1977; Downing et al., 2009; Carrió et al., 2016).

Problem-based learning (PBL) empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem (Savery, 2006). Researchers define PBL as a focused and experiential learning organized around the investigation, explanation, and resolution of meaningful problems, in which students work in

small collaborative groups, and learn what they need to know to solve a problem (Hmelo-Silver, 2004). During this learning cycle, learners identify knowledge deficiencies related to the problem, seek learning resources to acquire this knowledge and apply it to address the problem by integrating a wide range of disciplines (Savery, 2006; Schmidt et al., 2011).

The PBL methodology promotes cognitive, intrapersonal, interpersonal and technical skills. These have been highlighted as 21st century skills that must be built into curricula, developed, and assessed in higher education (Geisinger, 2016). The PBL learning process addresses the effective development of transversal and research skills. As a self-regulated learning method, students are responsible for monitoring the problem-solving process, which includes setting the learning goals, drawing up a working plan, selecting and evaluating the learning resources, extracting the most relevant ideas and using them to develop possible solutions to the problem, and finally, reflecting on their results. Overall, this process favors the development of metacognition skills and increases motivation and engagement for learning (Downing et al., 2009). Since learning takes place in a collaborative work environment, students can work intensively on teamwork skills that involve using interpersonal communication skills, responsibility, personal autonomy, initiative and time management. On the other hand, challenging students with real-life problems allows them to develop critical thinking and creativity, as they have to analyze complex problems from different perspectives and disciplines and work out possible, innovative solutions. To this end, students must critically assess different sources of information, contrast them, and select the most appropriate for their goals. In addition, as PBL promotes students to share their knowledge, experiences, opinions, and values with other group members, it facilitates the integration of multiple perspectives as part of the problem-solving process (Rodríguez et al., 2019; Kardoyo et al., 2020). At the end, they are often asked to present their results in scientific reports or oral presentations, which allows them to develop scientific communication skills as well (Sari et al., 2021). In fact, there seems to be a close connection between the opportunities offered by PBL to develop the skills we have called transversal, covering communication, teamwork, critical use of information, time management and self-directed learning, and the skills we have named research skills, which include identifying relevant research questions, formulating hypotheses, collecting data, and analyzing and discussing results (Murray-Harvey et al., 2005).

The way in which PBL is implemented in the curricula and the educational settings can be critical for its success in achieving the intended learning outcomes. According to the degree of self-directedness, learning processes, and problem structuredness, different PBL models have also been used (Barrows, 1996). Issues related to human factors, such as behaviors of students and tutors, small group interactions, and resources and workload, might also affect students' learning outcomes. Thus, when implementing PBL, it is important to consider which model will produce the desired effects by taking into account the learners' characteristics and instructional needs (Hung, 2011).

In our school, PBL was initially implemented with a hybrid model, in which an integrated module of different subjects was created (Carrió et al., 2016). Due to the difficulty of coordinating these modules, a new strategy of implementation based on interdisciplinary PBL courses was introduced (Carrió et al., 2018). The main difference between the PBL-modules and PBL-courses models was that the first one was an organized activity between different subjects and the second one was an interdisciplinary subject that only used PBL as a teaching method. This new model allowed us to improve the effectiveness of its implementation. This study compares these two hybrid PBL implementation models in order to identify the key elements for an effective implementation. For this purpose we rely on the students' and tutors' perceptions of competence development, as well as on their perceived usefulness and overall satisfaction.

MATERIALS AND METHODS

Research Context

In 2004, our School started a pilot study to explore the feasibility of creating a hybrid model of teaching that included PBL and a traditional approach into the Bachelor of Biology. In this study, 20% of the teaching time was devoted to PBL, and the remaining time was used for activities such as lectures, lab courses, and seminars. An integrated module, with interdisciplinary problems including learning objectives from the different subjects of the term, was designed. The objective of this module was to work on the subject specific skills together with research skills (identification of research questions, formulation of hypotheses, data collection and analysis, and discussion of results) and transversal skills (communication, teamwork, critical search for information, time management and autonomy). All faculty members of each subject participated in the PBL scenarios design and PBL tutorial sessions as tutors. The student workload for the PBL-module was 10 h per week during the whole academic year, distributed in 2 h of tutorial session with tutor, 2 h of group work without tutor and 6 h of students' self-study (research and analysis of information, preparation of sessions and assignments) and students solved a total of nine problems throughout the year. In this model, each problem was tutored by a different tutor (Carrió et al., 2016). In the context of this article, we called this pilot study the PBL-module.

With the implementation of the new Bachelors of Human Biology and of Medicine, following the Higher Education European Space in 2008–2009, the hybrid PBL model shifted to the implementation of two interdisciplinary PBL courses in Human Biology (Integrated Biomedicine I and II) and three in Medicine (Integrated Medicine I, II, and IV). Each course had four ECTS, lasted 10 weeks, worked in 6 groups of 8–10 students, each group had the same tutor for the whole course and solved four interdisciplinary problems. The student workload was 10 h per week, including a tutorial session of 2 h per week. Different assessment tasks were planned to assess both learning process and outcomes, including self- and peer-assessment of student participation, written reports, oral presentations, and final exams. Tutors assessed the participation of the students in their group and the outcomes of other groups. For each PBL-course, a team of 6 teachers from different specialities was created who were

TABLE 1 | Characteristics of PBL-modules and PBL-courses.

	PBL-modules	PBL-courses
Curriculum integration	It is an integrated activity of subjects taught in the same term. These are coordinated to design PBL problems that include learning outcomes from different subjects. The activity is carried out throughout the academic year and is compulsory for all students.	The curriculum includes compulsory subjects that are taught entirely with pure PBL. Each year has 1 PBL course lasting 1 term.
Problem design	Teachers of subjects that are taught in the same module design the problems together.	Each PBL-Course has a team of 6 teachers from different disciplines that design the problems together.
Tutors	*Short-term tutors*: all teachers of every subject participate as tutors, so each problem (2–3 weeks of duration) is tutored by a different tutor.	*Long-term tutors*: the teachers of the team act as tutors, so that each group has a tutor for the whole course (10 weeks).
Assessment	The assessment represents 10% of the mark for each subject. It includes: 1) Student participation in tutorial sessions, assessed by tutors and peers. 2) Assignments for each problem, assessed by teachers.	The assessment includes: 1) Student participation in tutorial sessions, assessed by tutors and peers. An observation grid of teamwork skills was included and used to give feedback to the students and plan improvements. 2) Assignments for each problem. Rubrics were included to evaluate the assignments, these were evaluated by 3 teachers and self- and peer-assessments were included. 3) Final triple jump exam.

TABLE 2 | Academic characteristics of the students in the PBL-courses. *Maximum score was 14.

Cohort	Students (*n*)		University entrance examinations scores*	
	HB	M	HB	M
2014–2015	45	49	11.5	11.8
2015–2016	42	46	11.6	12.3
2016–2017	46	49	12.1	12.6

HB, Human Biology; M, Medicine.

involved in writing the PBL scenarios, tutoring and evaluating the students. Most of them had also already been involved in the PBL-modules. This newer strategy is called PBL-courses in the context of this article. The differences between PBL-Module and PBL-Courses are summarized in **Table 1**.

Participants

This project was carried out during the academic years 2014–2015, 2015–2016, and 2016–2017. The students enrolled in these academic years were asked to answer a survey; 277 students accepted (72%), of which 133 were enrolled in the Bachelor of Human Biology (HB), and 144 in the Bachelors of Medicine (M). Students' sample corresponds to a 3.11% margin of error at a 95% confidence level. All HB participants were first- and second- year students and carried out the courses Integrated Biomedicine I and II, while all the M participants were first- and second- year students and carried out the courses Integrated Medicine I and II. Based on the university entrance examination scores, students had similar academic profiles (**Table 2**). Tutors were also asked to participate in the survey, and 50% (10 out of 20) accepted. For comparative purposes, some data were obtained from a previous study based on the pilot experience (PBL module) in the academic years 2005–2006, 2006–2007, and 2007–2008. Demographic and academic characteristics of the students who participated in this experience were similar to those of PBL-courses, being the university entrance examinations scores 10.5, 10.7, and 10.5 out of 14, respectively. In this study, 330 students and 34 tutors participated (Carrió et al., 2016, 2018).

Data Collection

This study used descriptive-evaluative research based on a mixed-method approach that integrates quantitative and qualitative data, which complement each other, to gain a clear and in-depth understanding of the research problem. Both data were collected in parallel through an anonymous questionnaire addressed to students and tutors, which was administered to them at the end of the course. A similar questionnaire to the one used in a previous study was constructed in order to compare the results with the previous model (PBL-module) (Carrió et al., 2016). To test reliability, the questionnaire was piloted with some students and tutors before it was administered. The questionnaire included a section of closed Likert-type questions and a section of open-ended questions. In the first section, students had to rate from 0 (not at all) to 10 (very much) the perceived skills development and their satisfaction with the learning experience, with the following questions (Q):

- Perception of transversal skills acquisition (6Q): oral communication, writing ability, teamwork, critical search of information, time management, and self-learning.
- Perception of research skills acquisition (5Q): identification of a relevant research question, hypothesis foundation, data collection, and analysis and discussion of findings.
- Learning experience (2Q): satisfaction and usefulness of the PBL activity.

In the second section, students were asked to identify strengths and weaknesses of PBL, to explain whether PBL had encouraged them to develop scientific creativity and to give their opinions on the learning experience.

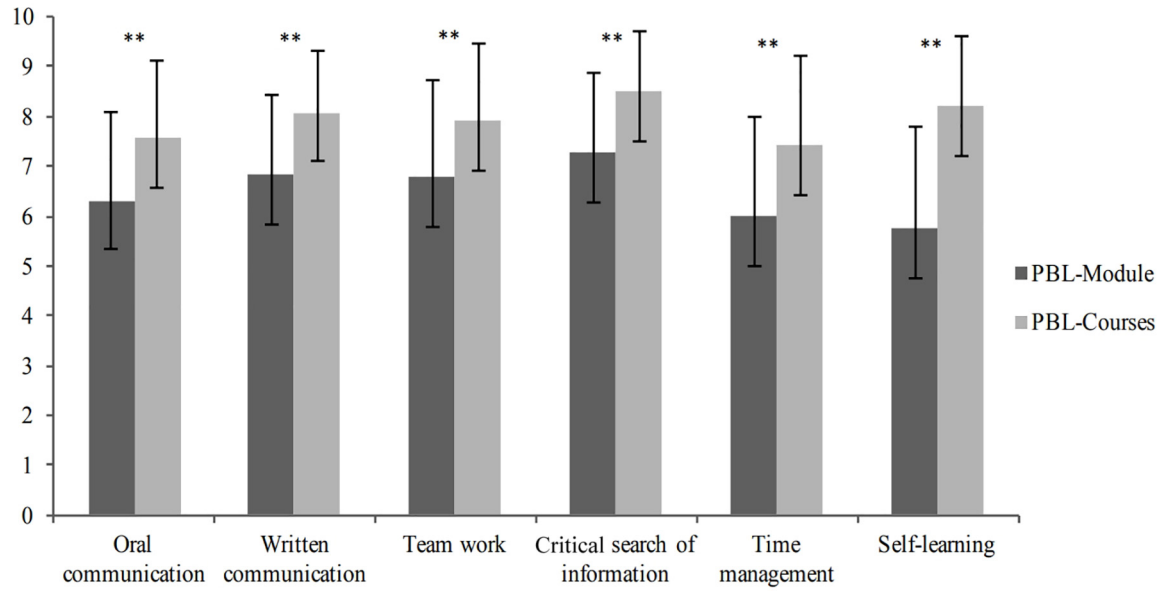

FIGURE 1 | Mean scores given by students in the transversal skills dimension in the PBL-module (n = 330 students) and PBL-courses (n = 277 students). $^{**}p < 0.01$ (OC, $p = 1.5\times10^{-19}$; WC, $p = 4.5\times10^{-25}$; TW, $p = 2.4\times10^{-15}$; CSI, $p = 1.1\times10^{-25}$; TM, $p = 2.2\times10^{-19}$; SL, $p = 3.8\times10^{-49}$).

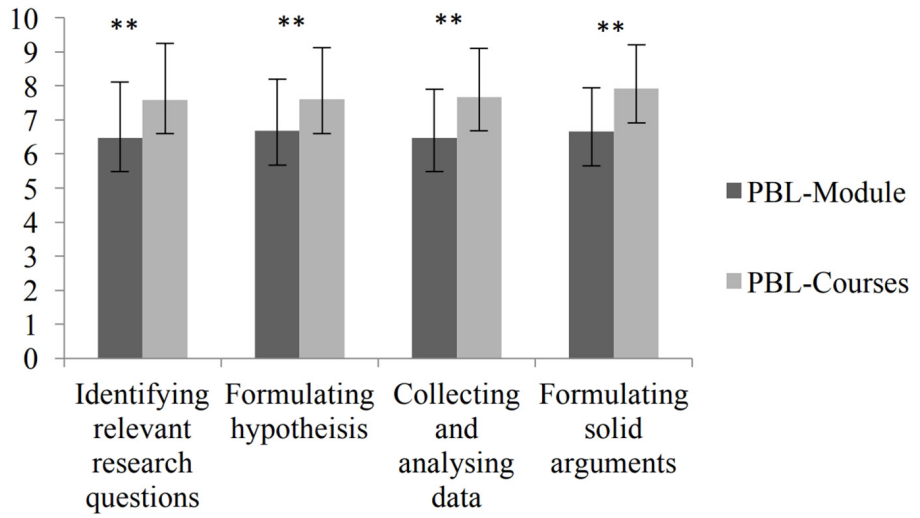

FIGURE 2 | Mean scores given by students in the research skills dimension in the PBL-module (n = 330 students) and PBL-Courses (n = 277 students). $^{**}p < 0.01$ (IRQ, $p = 4.9\times10^{-15}$; FH, $p = 3.08\times10^{-13}$; CAD, $p = 5.6\times10^{-22}$; FSA, $p = 7.4\times10^{-27}$).

In addition, data and results obtained from the previous study based on the PBL-Module used the same questionnaire (Carrió et al., 2018), making it possible to directly compare the outcome of the implementation of the two models.

Data Analysis

Data were analyzed both qualitatively and quantitatively. The SPSS software was used for statistical analysis. The Pearson correlation was used to analyze the correlation between the quantitative variables, as all variables have a linear relation. To determine whether there were differences between M and HB students, the independent samples t-test and Mann–Whitney U-test were used, depending on the variable (Connolly, 2007). Finally, to analyze the student and tutor open-ended responses, the qualitative content analysis approach was used as a technique within a constructivist paradigm. To do this, we reduced the data to codes or concepts that described the research findings by creating categories. Codes and categories that emerged during analysis were refined after multiple coding iterations of the content with the support of the research software Atlas.ti (Elo et al., 2014; Graneheim et al., 2017). Investigator triangulation and peer debriefing were used to ensure reliability.

TABLE 3 | Statistical analysis of the scores given by students (S) and tutors (T) on their perceptions on the development of skills included in the transversal and research skills dimensions, as well as the learning experience dimension, in the PBL-module (n = 330 students, n = 34 tutors) and the PBL-courses (n = 277 students, n = 10 tutors).

	Skills development				Learning experience			
PBL-module	**Transversal skills**		**Research skills**		**Satisfaction**		**Usefulness**	
	S	**T**	**S**	**T**	**S**	**T**	**S**	**T**
Mean	6.63	7.03	6.57	6.83	5.41	7.52	5.77	7.73
Median	6.80	7.12	6.75	7.00	6.00	8.00	6.00	8.00
SD	1.34	1.14	1.17	1.17	1.97	1.60	2.03	1.55
Variance	1.81	1.30	1.38	1.37	3.90	2.55	4.14	2.40
PBL-courses								
Mean	7.96	8.13	7.70	8.15	7.75	9.20	8.27	9.30
Median	8.00	8.00	7.75	8.25	8.00	9.00	9.00	9.50
SD	1.00	0.37	1.25	0.43	1.82	0.63	1.61	0.82
Variance	1.00	0.14	1.57	0.18	3.32	0.40	2.59	0.68

See section "Materials and methods" for details.

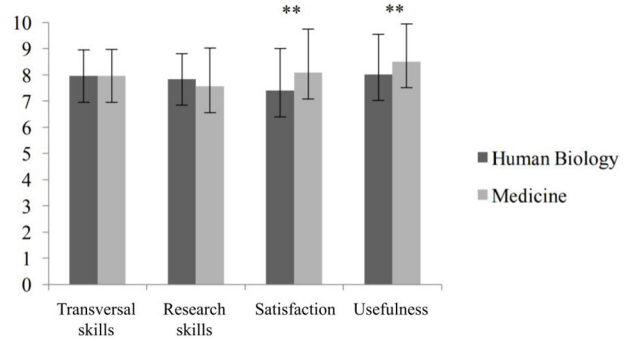

FIGURE 3 | Scores of student perceptions in the undergraduate bachelors of Human Biology (n = 133) and Medicine (n = 144) for the acquisition of transversal and research skills and learning experience dimensions (satisfaction and usefulness variables) in PBL-courses. Data are expressed as mean and SD. $^{**}p < 0.01$ (satisfaction, $p = 0.01$; usefulness, $p = 0.005$).

RESULTS

Comparison Between the Problem-Based Learning-Module and Problem-Based Learning-Courses

Acquisition of Transversal and Research Skills

Scores were given by students to each skill included under transversal skills dimension (**Figure 1**). Overall, the scores of PBL-Courses were significantly higher than those of the PBL-Module approach. The same was true for research skills: students from PBL-Courses gave higher scores than those from PBL-Module (**Figure 2**).

Students in PBL-Courses assessed the acquisition of transversal and research skills scored significantly higher than those of PBL-module (**Table 3**).

TABLE 4 | Pearson correlation analysis between the student perceptions about the acquisition of transversal skills and research skills, and their evaluation of satisfaction and usefulness, for the PBL-courses (n = 277 students).

	Transversal skills	**Research skills**	**Satisfaction**	**Usefulness**
Transversal skills	$r = 1$	–	–	–
Research skills	$r = 0.622^{**}$	$r = 1$	–	–
Satisfaction	$r = 0.509^{**}$	$r = 0.558^{**}$	$r = 1$	–
Usefulness	$r = 0.444^{**}$	$r = 0.567^{**}$	$r = 0.767^{**}$	$r = 1$

$^{**}p = 0.01$ (bilateral).

Notably, the tutors' perceptions of the acquisition of transversal and research skills through PBL scored higher than students in both PBL-Module and PBL-courses (**Table 2**). Significant differences were also observed between the perception of tutors who participated in the PBL-Courses and those who participated in the PBL-Module. Tutors felt that transversal and research skills were better developed in PBL-courses than in the PBL-Module.

Assessment of the Learning Experience

The student and tutor evaluations of satisfaction and usefulness of the PBL approaches are depicted in **Table 2**. The students gave high scores to the variables of satisfaction and usefulness in the PBL-Courses. These values are significantly higher than those obtained with the PBL-module. As observed for the skills evaluation, tutors scored both variables higher than the students (**Table 2**). Similar to students, tutors scored the satisfaction and usefulness of the methodology higher in PBL-Courses than in PBL-Module.

Analysis of Problem-Based Learning-Courses

Comparison Between Human Biology and Medicine Students

Students' perceptions of skills acquisition and the learning experience dimensions are shown in **Figure 3**. Statistical differences were found between HB and M students in satisfaction and usefulness variables: HB students scored them with a 7.40 and 8.02, respectively, while M students scored them higher, with 8.08 and 8.51, respectively.

Correlations Among Skills Development and Learning Experience

All the correlations between the analyzed variables in PBL courses were statistically significant (0.01 level) (**Table 4**). A strong correlation (> 0.6) was found between the development of transversal and research skills. Moreover, there was a strong correlation between the satisfaction with the PBL-courses and their perceived usefulness. Other significant correlations have been found between the satisfaction and the development of transversal and research skills and between the usefulness of the courses and the development of transversal and research skills.

Qualitative Analysis of the Implementation of Problem-Based Learning-Courses

We also analyzed the development of transversal and research skills using qualitative data obtained from the BH and M student comments on the PBL-courses from the first and second year (SC-BH1,2 and SC-M1,2). In this analysis, we identified two main categories: the learning process and the learning outcomes.

Regarding the learning process category, students highlighted the benefits of social interactions in the process of knowledge construction that takes place in PBL. Specifically, they commented that working with peers made them integrate each one's ideas, perspectives, and points of view. They also recognized that having to analyze cooperatively the situation and propose ideas to apply and integrate knowledge from different fields to look for a solution to the problem facilitates their learning process.

> Through cooperative work, we learn to share and collaborate and also to integrate each other's ideas [SC-BH2].

> We learn while solving a problem in a group with knowledge that we have to first look for and then apply [SC-M1].

Regarding the second category, students identified transversal and research skills as the main learning outcomes. They were aware of their own development in transversal skills such as cooperative work, communication skills, critical search of information, and self-directed learning.

> We learn to dialogue and communicate better among ourselves [SC-BH2].

> It empowers our self-learning capacity, since we have to know what we have to learn [SC-M2].

They also gained experience in research skills, formulating hypothesis from an unstructured scenario, analyzing problems, looking for solutions, and evaluating their final outcome as shown by statements such as:

> We have learned how to analyze complex mechanisms [SC-BH1].

> We have to think about new questions and discuss what we know to solve a problem [SC-BH1].

Integrating different perspectives, formulating new ideas, relating knowledge from different fields, and doing research makes students develop their creative thinking, as they also state:

> We ask questions and then research them, so we analyze knowledge deeply, and we can think and reflect differently than before [SC-M2].

> Working with different peers makes us integrate different perspectives and think about different hypotheses and questions [SC-BH2].

The students' learning experiences through the PBL methodology was also analyzed using qualitative data obtained from the student comments. Five main categories were identified: satisfaction, usefulness, role of tutor, evaluation, and limitations.

- Satisfaction: Students were satisfied with the methodology and perceived that PBL promotes long-term retention of knowledge and acquisition of skills.

  > This methodology is more effective than traditional learning because we consolidate knowledge in a better and deeper way [SCM-M2].

- Usefulness: Students consider that PBL is useful for their professional future and that the skills they learn are important for their development. M students emphasize this aspect more than HB students.

  > I think this kind of methodology is very positive and essential for our development as future professionals of health sciences [SC-M2].

- Role of tutors: Students identified the role of the tutor as relevant. They pointed out that there are different kinds of tutors; most considered tutors with previous experience in PBL, who guide and act as facilitators, to be ideal.

  > It would be nice if all tutors had the same, concrete indications to guide the sessions in a proper way, and if too directive tutors could be avoided [SC-BH2].

- Evaluation: Students perceived the evaluation in a positive way, although they noted that some criteria are subjective, and that the tutor can influence the qualifications.

  > I think that in some evaluations, some criteria are subjective and differ according to the tutor [SC-BH1].

- Limitations: Students identified some limitations of the methodology, such as organizational issues, variability of tutor instructions, and small group issues.

  > Small groups are suitable for performing PBL, however, sometimes there is tension between us [SC-BH1].

  > Some tutors do more commentaries than others tutors. PBL is easier for the groups that have atutor that gives more guidance [SC-BH2].

DISCUSSION

This study examines the acquisition of transversal and research skills through the implementation of interdisciplinary PBL courses in M and HB students. Based on the assessment of a previous pilot experience (Carrió et al., 2018), these courses were designed to improve the development of transversal and research skills and increase their satisfaction with the methodology. For this reason, the implementation model shifted from a PBL-Module within traditional subjects, to fully integrated PBL-Courses. Given the satisfactory results obtained, PBL courses were implemented and they are still used in the training of our students.

Students' and tutors' perceptions about the acquisition of transversal and research skills were significantly enhanced in the PBL-Courses. This improvement can be attributed to the clarification of learning outcomes, skills-oriented evaluation and the role of the tutor as facilitator. In PBL-Courses, learning outcomes are clearly focused on transversal and research skills, while in PBL-Module, these skills could be blurred within the other learning outcomes from the traditional subjects. Consequently, assessment in PBL-Courses is skill-oriented and uses different tools, such as rubrics and observation grids, to guide the skills development. The results suggest that students in PBL-Courses have better assimilated the intended learning goals, and that assessment tools might have contributed to improving their skills acquisition.

According to Chng et al. (2014), the tutor plays a relevant role in facilitating student learning; thus, rather than simply conveying knowledge, the tutors question, make suggestions, and challenge the ideas raised by students. This task demands a great amount of time and preparation; furthermore, the better the tutor knows the students and the group interactions, the better he/she can guide the students' learning processes. In PBL-courses, the same tutor was present for the full 10-week course; in contrast, in the PBL-module, tutors changed for every problem, and each tutor was only present for 3 weeks. Therefore, we partly attribute the improvement of the students' skills development to having long-term tutors. In fact, previous studies have already found that students rated long-term tutors higher than short-term tutors (Curet and Mennin, 2003). So, we felt that this was a key element for the success of the PBL-Courses implementation model.

Our results also suggest that both students and tutors perceived that the students developed a high level of transversal and research skills acquisition in PBL-Courses. Additionally, the results showed a strong correlation between the acquisition of transversal and research skills, which were corroborated by the qualitative data collected from students' comments. The correlation between the development of transversal and research competences was already found in a previous study conducted in our School in the context of project-based learning (Rodríguez et al., 2019). Similar results have also been found in other hybrid PBL curricula. Demirören et al. (2016) reported that students perceived that they effectively developed self-regulated learning skills during PBL and that these were related to responsibility for learning, teamwork and self-efficacy.

Active learning and student-centered methodologies, such as PBL, imply that learners play an active role in planning, monitoring, and evaluating the learning process. Thus, students have to consider different ways to approach a task, set clear goals, select strategies for achieving these goals, anticipate what has to be done, and evaluate the process and the product of the learning cycle (Dolmans et al., 2005). Development of both transversal and research skills are intrinsically tied to this process. In this light, the strong correlation between the acquisition of these two sets of skills is not surprising. In fact, the ability to become a knowledge seeker, to be able to collaborate and communicate, and to self-direct this learning process are essential skills necessary for defining a problem, analyzing the situation, and integrating and applying knowledge to develop solutions for new situations (Hmelo-Silver, 2004; Murray-Harvey et al., 2005; Joham and Clarke, 2012).

Both students and tutors in the PBL-Courses were more satisfied overall than those in the PBL-Module, and those in PBL-Courses scored the usefulness of this pedagogical approach higher. Notably, significant differences between the students of the different bachelors have been found in PBL-Courses. Because satisfaction and usefulness show a strong correlation to each other, the differences in these two items can be attributed to the perception that M students find learning through PBL more focused for their future professional lives than do HB students.

Students who took the PBL-Courses stated that they were satisfied with this methodology as it allowed them to develop useful skills, which is also demonstrated by the high correlation between satisfaction and usefulness, and the self-perceived transversal and research skills acquisition. Also, students perceived that they retained the knowledge gained over the long term, as has been previously shown (Spronken-Smith and Walker, 2010). These higher cognitive abilities, such as problem-solving, collaboration, or creative thinking, will be required to confront new future and social challenges in our ever-changing world (Justice et al., 2009; Waldrop, 2015; Bosch and Casadevall, 2017).

Our study has several limitations, the most important of which is related to its own characteristics. The overarching aim of the study was to explore whether changing the PBL implementation model enhanced the perceived improvement of students' learning outcomes and satisfaction with the learning experience. It was performed in a naturalistic academic environment, and no experimental interventions were carried out. In this non-interventional design, many variables changed between the two models that were compared. Consequently, we cannot identify which factors contributed the most to enhancing the aspects analyzed. For instance, we cannot rule out that students who participated in the PBL-courses had a higher acceptance of the methodology due to a generational factor. It is also possible that the PBL experience acquired by the tutors had a relevant effect on the improvement of the results. Another limitation is the lack of evidence of the actual student development in transversal, and research skills in each model. This was not possible as the assessment methods used in these models were not comparable; therefore, we focused the study on perceptions of students and tutors. However, we consider that our results are of interest as they show significant differences between both models, and describe how these skills were developed, from the students' and tutors' perspectives.

CONCLUSION

We conclude that the shift from PBL-Module to full PBL-Courses improved the students' and tutors' perceptions about the improvement in the acquisition of transversal and research skills, their opinion about the educational value of this pedagogical approach and their satisfaction with their learning experience. We found that the main educational settings in the PBL-Courses that contributed to this improvement were (i) the use

of assessment tools that facilitate skills development, and (ii) the maintenance of the same tutor for the entire course duration. Correlation analyses showed the important relationship between the acquisition of transversal and research skills as well as between perception of the usefulness of the PBL activities and satisfaction with the experience. This is especially important as student satisfaction may enhance the student engagement, thereby leading to improved learning. Finally, the results of this study suggest that PBL-Courses are a suitable pedagogical approach to develop transversal and research skills, which have been identified as crucial issues in the higher education of the 21st century (Geisinger, 2016).

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

GR made substantial contributions to the study design, acquisition, analysis, and interpretation of data, was responsible for surveying the participants through the questionnaires, observing the PBL tutorial sessions, and analyzing the data (quantitative and qualitative), drafted the conclusions, was also involved in writing the manuscript, and also gave final approval of the version to be published. MC contributed to the study design, data collection, analysis, and interpretation of data, independently carried out the analysis of the data for the qualitative data analysis process, then discussed, and agreed with themes jointly with GR, was the academic coordinator of the PBL-module and PBL-courses that are analyzed in this research, and was also involved in writing the manuscript, revising it critically, and giving the final approval of the version to be published. J-EB was involved in writing and revising the manuscript critically for important intellectual content and gave final approval of the version to be published. All authors contributed to the article and approved the submitted version.

ETHICS STATEMENT

The Academic Coordination Office Board of the School of Health and Life Sciences approved the study protocol. The protocol required that participants were informed of the project's objectives and methods; participation was voluntary and anonymous. Students were informed of the characteristics of the study, gave their oral consent to participate, and agreed to fulfill study requirements. Since participation was voluntary and all data collected were anonymous, written informed consent was considered unnecessary.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2022.875860/full#supplementary-material

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