Dental Students' Perceived Clinical Competence in Prosthodontics: Comparison of Traditional and Problem-Based Learning Methodologies

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Abstract: The aim of this study was to compare the perceived competence for treating prosthodontic patients of two samples of fourth-year dental students: those educated using traditional methodologies and those educated using problem-based learning (PBL). Two cohorts of fourth-year dental students at a dental school in Spain were surveyed: the traditional methods cohort (n=46) was comprised of all students in academic years 2012 and 2013, and the PBL cohort (n=57) was comprised of all students in academic years 2014 and 2015. Students in both cohorts reported the number of prosthodontic treatments they carried out per year and their perceived level of competence in performing such treatments. The results showed that the average number of treatments performed was similar for the two cohorts, except the number of metal-based removable partial dentures was significantly higher for students in the traditional (0.8±1.0) than the PBL (0.4±0.6) cohort. The level of perceived competence to treat complete denture patients for the combined cohorts was significantly higher (7.3±1.1) than that for partial acrylic dentures (6.7±1.5) and combined dentures (5.7±1.3). Students' clinical competence in prosthodontics mainly depended on number of treatments performed as the operator as well as the assistant. Students in the traditional methods cohort considered themselves to be significantly more competent at treating patients for removable partial and fixed prostheses (7.8±1.1 and 7.6±1.1, respectively) than did students in the PBL cohort (6.4±1.5 and 6.6±1.5, respectively). Overall, however, the study found that practical experiences were more important than the teaching method used to achieve students' perceived competence.

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Dentistry is a profession that requires a broad understanding of a wide spectrum of basic and health-related sciences. Educational methodologies have changed worldwide in the last two decades towards a student-centered approach and competency-based learning, which replaces the classical teacher-centered strategy of information-oriented learning.[1] Competency-based education was introduced to North American dental schools in 1993 when Chambers proposed that "competencies are skills essential to beginning the practice of dentistry."[2] Dental competence may be defined as the combination of knowledge, skills, and attitudes appropriate to performing the individual aspects of the dental profession,[3] although this requirement is usually defined as the minimum acceptable level of performance for a recently graduated dentist. The clinical skills of general dentistry require mechanical hand activities that rely on developing psychomotor skills during preclinical and clinical training practices

that have remained essentially the same over the years (typodonts, laboratory tasks, and prosthodontic patients).[4] Clinical training in dentistry involves performing irreversible operative procedures on patients for whom students are personally responsible, but with the faculty supervisor assuming legal risks.

In 2010, in the European Higher Education Area, the Bologna Process for University Degrees was implemented as a requirement for all countries that signed the Bologna Accord.[5] This initiative resulted in a change in the structure of dental curricula, but also reoriented teaching methodologies towards student-centered learning to ensure proper acquisition of the various clinical competences. According to Plasschaert et al., implementation of this new plan in European dental schools should make teaching more student-centered and flexible and at the same time support a variety of learning styles.[3]

Problem-based learning (PBL) is an approach in which a problem serves as the stimulus for active learning: this pedagogy is based on small groups of students working together and collaborating with faculty facilitators to achieve understanding.[6] PBL is intended to enhance learning skills by engaging students through self-direction and problem-solving and also to nurture clinical reasoning, teamwork, and communication skills. Prior to the introduction of new dental curricula, traditional teaching methods mainly involved transmitting knowledge from the teacher to the students and was very much teacher-centered.

Prosthodontic training is one of the largest components of dental curricula, so gaining competence in prosthodontics is essential. The current profile of the European dentist states that "a dentist must be competent at designing effective indirect restorations, anterior and posterior crowns, bridges, complete and partial dentures, including a combination of fixed and removable dentures, and occlusal splints, and undertaking some of these procedures as is relevant to the country of practice."[7] Most surveys of education in prosthodontics have been oriented towards clinical materials and techniques,[8-10] preclinical skills,[11] and teaching strategies for complete[12] or partial dentures,[13] but only one study has addressed students' perceptions of their own clinical competence for treating prosthodontic patients.[14] The aim of our study was to compare the perceived competence for treating prosthodontic patients of two samples of fourth-year dental students: those educated using traditional methodologies and those educated using PBL.

Material and Methods

This study was approved by the Institutional Plan for the Innovation of Teaching of the University of Salamanca, Salamanca, Spain (PID_ID12/190). To carry out this study, we conducted surveys of two cohorts of fourth-year dental students: one cohort educated with traditional teaching methods (n=46), comprised of students in two consecutive academic years (2012 and 2013), and the other cohort educated with PBL (n=57), comprised of students in academic years 2014 and 2015.

The survey was conducted at the end of the teaching period but before final exams (June-July). We designed the survey instrument to capture students' perceptions of their competence to diagnose and treat patients with prosthodontic needs. The number of prosthodontic treatments performed by each student as the operator and as the assistant was recorded, along with students' perceived level of competence to perform such prosthodontic treatments as complete dentures (CDs), acrylic removable partial dentures (A-RPDs), metal-based removable partial dentures (M-RPDs), fixed partial dentures (FPDs), or a combination of the latter two by means of frictional attachments such as mixed prostheses (MPs). Students rated their competence on a scale from 0 to 10.

Currently, in the five-year dental curriculum of the Faculty of Medicine at the University of Salamanca, the subject of prosthodontics is taught via a hybrid PBL format (lectures plus problem-based seminars), which includes Prosthesis I (12 European Credit Transfer and Accumulation System credits [ECTS]) in the third year, Prosthesis II (12 ECTS) in the fourth year, and Prosthesis III (6 ECTS) in the first semester of the fifth year. Previously, prosthodontics was taught in the third and fourth years and was comprised of two subjects of 13 credits each (one Spanish credit was equal to ten hours of face-to-face teaching). In the PBL program, all didactic topics are summarized in 10-15-minute videos that are discussed during one-hour-per-week seminars with the guidance of a lecturer. Clinical sessions with small groups are frequently used to complement the videos and stimulate clinical decision making. By contrast, students in the traditional methodologies cohort received lectures delivered face-to-face, lasting two hours per week, which included a brief discussion or summary of the lecture at the end of the class.

In both the traditional and PBL methodologies, preclinical and clinical skills have been based on the same teaching experiences (typodonts and patients, respectively) for three hours per week. In both programs, preclinical practice has been carried out individually, but in clinical practice students work in trios (operator, nurse, and assistant). In both programs, thematic modules with material on physiological dental occlusion and removable dentures have been taught in the third year, and fixed prosthodontics and frictional attachments have been taught in the fourth year. The modules on implant dentistry and occlusal pathology were taught during the fourth year in the traditional program; in the new PBL program, they are taught in the first semester of the fifth year. The main similarities and differences of the two programs are shown in Figure 1.

For statistical analyses, we compared the data distribution of the two student cohorts (traditional vs. PBL) by means of chi-square test and Student's t-test. The paired t-test was used to compare the level of competence for each type of intervention for each group. Pearson correlation coefficients were used to assess the linear association between the final teacher-based evaluation with the number of treatments performed and the level of competence perceived. A linear regression analysis was used for predicting students' prosthodontic clinical competence after inclusion of the potentially related variables. The Statistical Package for the Social Sciences, version 20 (SPSS Inc., Chicago, IL, USA) was used for the statistical analyses. The cutoff level for statistical significance was 0.05.

Results

The students were mostly female (66%) with an average age of 21.7±0.7 years. The mean age (SD) of students in the two cohorts was similar: 21.5 years (0.7) in the traditional cohort and 21.8 years (0.7) in the PBL cohort. In general, both cohorts of students (Table 1) reported feeling quite or very confident in

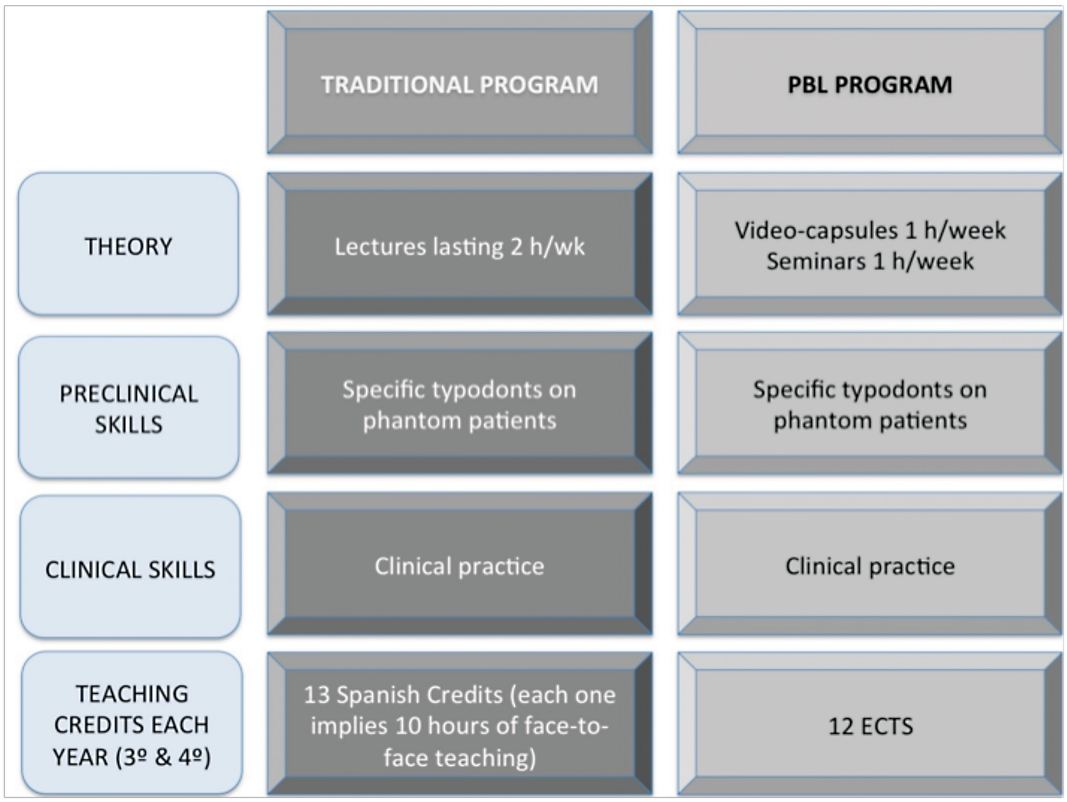

Figure 1. Main similarities and differences of traditional and problem-based learning (PBL) curricula at University of Salamanca

ECTS=European Credit Transfer and Accumulation System credits

Table 1. Self-perceived performance of study sample, by number and percentage of students in each cohort

Variable	Students in Traditional Cohort (n=46) Number	Percent	Students in PBL Cohort (n=57) Number	Percent
How sure are you of your clinical practice?				
Very confident	2	4.3%	3	5.3%
Quite confident	42	91.3%	48	84.2%
Normal	2	4.3%	3	5.3%
Not very confident	0	–	3	5.3%
Did the time allocated to carry out the treatments match the actual time taken?				
Perfectly matched	4	8.7%	8	14.0%
Well matched	31	67.4%	42	73.7%
Regular	7	15.2%	4	7.0%
Quite unmatched	4	8.7%	2	3.5%
Very unmatched	0	–	1	1.8%
Do you feel you have sufficient theoretical knowledge to carry out clinical training?				
All	5	10.9%	2	3.5%
Enough	37	80.4%	47	82.5%
Some	4	8.7%	8	14.1%
Do you feel you were able to coordinate clinical tasks with the student assistant in an effective manner?				
Very effectively	12	26.1%	8	14.0%
Quite effectively	26	56.5%	44	77.2%
Normal	6	13.0%	2	3.5%
No	2	4.3%	3	5.3%
Did you feel you worked well with your classmate?				
Not really	2	4.3%	3	5.3%
Yes	44	95.2%	54	94.7%
Do you feel you learned from your classmate?				
Little or nothing	5	10.9%	11	19.3%
A lot or some	41	89.1%	46	80.7%
Had you previously utilized the materials used in the clinical training?				
Yes, frequently	10	21.7%	4	7.0%
Once	33	71.7%	46	80.7%
Never	3	6.5%	7	12.3%
Do you consider yourself manually skillful enough to carry out clinical training?*				
Very skillful	3	6.5%	0	–
Skillful enough	38	82.6%	42	73.7%
Normal	5	10.9%	15	26.3%
Do you consider your preclinical training (classes, seminars, and clinical sessions) was sufficient to treat a patient?				
Yes	11	23.9%	16	28.1%
Quite	26	56.5%	26	45.6%
Normal	8	17.4%	8	14.0%
A little	1	2.2%	7	12.3%
Have you felt supported by your teacher during clinical training?				
Yes	30	65.2%	36	63.2%
Quite	14	30.4%	19	33.3%
Normal	1	2.2%	1	1.8%
A little	1	2.2%	1	1.8%
Have you found any differences when training with typodonts versus real-life patients?				
Yes, many	20	43.5%	20	35.1%
Quite different	21	45.7%	31	54.4%
Slightly different	5	10.9%	6	10.5%

*Significant intergroup difference after chi-square test

their clinical practices (92.2%), and most (70.9%) considered the time allocated to carrying out various treatments matched the actual time spent treating the patient. High percentages of students in the combined cohorts reported feeling that they coordinated with the student acting as the dental assistant in an efficient manner (87.4%), that they formed a good team (94.2%), and that they helped each other (95.1%). Of the total students in both cohorts, 90.3% had previously used the materials used in the practical training sessions, and 96.1% reported feeling supported by the teacher. A high percentage of students in the traditional cohort (89.1%) considered themselves to be quite or very manually skillful as compared to 73.7% of students in the PBL cohort.

Overall, high percentages of the combined cohorts considered that their preclinical training had allowed them to acquire the required competences for treating patients (76.7%) and that the theoretical education they had received was also satisfactory for treating patients (88.3%). However, 89.3% reported feeling the differences between practical training using typodonts and real-life patients were either many or quite different.

Smaller percentages of the combined cohorts identified their weak points as oral expression (47.6%), theoretical knowledge (26.2%), and the required manual skill (17.5%) (Table 2). The difficulties perceived regarding clinical practices were significantly different between the two cohorts: students

Table 2. Students' responses to survey questions, by number and percentage of respondents in each cohort

Question	Students in Traditional Cohort (n=46) Number	Percent	Students in PBL Cohort (n=57) Number	Percent
In your opinion, what was the cause of difficulties experienced during practical training?*				
Laboratory	33	71.7%	11	19.3%
Not preparing for case properly	3	6.5%	14	24.6%
Manual technique	8	17.4%	22	38.6%
Handling of materials	1	2.2%	8	14.0%
Lack of theoretical knowledge	1	2.2%	2	3.5%
I consider my weak points to be:				
Theoretical knowledge	13	28.3%	14	24.6%
Oral expression	21	45.7%	28	49.1%
Communication with patient	5	10.9%	4	7.0%
Manual skill	7	15.2%	11	19.3%
Do you feel it was helpful for the teacher to give you more freedom in clinical training?				
Yes, for some treatments	36	78.3%	44	77.2%
No	10	21.7%	13	22.8%
Has the dental laboratory fulfilled your expectations?*				
No (somewhat or normal)	37	80.4%	25	43.9%
Yes (a lot or quite)	9	19.6%	32	56.1%
Have the patients you treated respected follow-up appointments?				
No (somewhat or normal)	6	13.0%	5	8.8%
Yes (a lot or quite)	40	87.0%	52	91.2%
Do you feel you transmitted a confident attitude to the patients you treated?				
No (somewhat or normal)	5	10.9%	3	5.2%
Yes (a lot or quite)	41	89.1%	54	94.8%
Do you feel the patients showed a collaborative attitude?				
No (somewhat or normal)	5	10.9%	3	5.2%
Yes (a lot or quite)	41	89.1%	54	94.8%
Which teaching activity would you increase to improve your training?				
Theory	0	–	4	7.0%
Clinical sessions	15	32.6%	23	40.4%
Practical training	25	54.3%	28	49.1%
Seminars	2	4.3%	0	–
None of the above	4	8.7%	2	3.5%

Note: Percentages may not total 100% because of rounding.

*Significant intergroup differences after chi-square tests ($p<0.01$)

in the traditional cohort felt laboratory work was the main difficulty (71.7%), while students in the PBL cohort felt the main difficulty was manual technique (38.6%). In fact, in the traditional cohort, a large majority of students (80.4%) reported that laboratory work had not fulfilled their expectations as compared to only 43.9% of students in the PBL cohort. High percentages of students in the combined cohorts perceived they were able to transmit a confident attitude to the patients they treated (92.2%) and that the patients had demonstrated a collaborative attitude (92.2%) and respected the instructions and follow-up appointments (89.3%). Smaller percentages reported feeling their training would be improved by increasing the amount of practical training (51.1%) or number of clinical sessions (36.9%).

Table 3 shows the quantitative results of students' clinical performance. The students, acting as the operator, conducted on average 0.8±0.7 CDs, 0.7±0.6 A-RPDs, 0.8±0.6 M-RPDs, 0.4±0.7 FPDs, and 0.1±0.4 MPs, as well as 1.3±1.3 dental extractions. The average number of treatments acting as the assistant was similar. Except for the number of M-RPDs, which was significantly higher for students in the traditional cohort, the average number of treatments performed was similar for the two cohorts. On average, the level of competence perceived by the total students was satisfactory (>5) for all of the treatments assessed, but was significantly higher for CDs (7.3±1.1) than for A-RPDs (6.7±1.5) or frictional attachments prostheses (5.7±1.3).

There were no significant differences between males and females on all the competencies assessed. An interesting finding was that the instructor's final evaluation of the students was not significantly correlated with the level of competence perceived by PBL students on all the treatments evaluated. However, for students in the traditional cohort, the final evaluation was significantly correlated with the level of competence for CDs ($r=0.31$; $p<0.05$), A-RPDs ($r=0.42$; $p<0.01$), and M-RPDs ($r=0.26$; $p<0.05$). The overall academic performance of the two cohorts was similar: 6.5±1.3 for the traditional cohort vs. 6.6±0.9 for the PBL cohort.

Table 3. Number of prosthodontic treatments conducted as operator (dentist) and dental assistant during academic year and students' self-rated clinical competence on 0-10 scale

	Students in Traditional Cohort (n=46)			Students in PBL Cohort (n=57)		
Quantitative Clinical Performance	Mean	SD	Range	Mean	SD	Range
Complete dentures						
Operator (number)	0.6	0.9	0-4	0.8	0.8	0-3
Assistant (number)	0.5	0.9	0-4	0.6	0.6	0-2
Clinical competence rating	7.5	1.2	5-10	7.2	1.1	5-10
Acrylic partial dentures						
Operator (number)	0.5	0.7	0-2	0.6	0.7	0-3
Assistant (number)	0.5	0.7	0-2	0.6	0.7	0-3
Clinical competence rating	7.1	1.4	3-10	6.4	1.6	1-9
Metal-based partial dentures						
Operator (number)	0.8	1.0	0-3	0.4	0.6	0-2
Assistant (number)	1.1	1.0	0-5	0.4	0.6	0-2
Clinical competence rating	7.8	1.1	5-10	6.4	1.5	3-9
Fixed partial dentures						
Operator (number)	0.5	0.7	0-3	0.4	0.7	0-3
Assistant (number)	0.5	0.6	0-2	0.3	0.7	0-3
Clinical competence rating	7.6	1.1	4-10	6.6	1.5	2-9
Frictional attachments prostheses						
Operator (number)	0.1	0.4	0-2	0.2	0.5	0-2
Assistant (number)	0.1	0.3	0-1	0.2	0.5	0-2
Clinical competence rating	5.8	1.0	4-8	5.7	1.5	2-9
Tooth extractions						
Operator (number)	1.3	1.3	0-4	1.3	1.2	0-5
Assistant (number)	1.6	1.4	0-5	1.2	1.0	0-4
Clinical competence rating	6.8	1.5	3-9	6.9	1.2	4-9

Students' perceived clinical competence in prosthodontics mainly depended on the number of treatments carried out as the operator as well as the assistant (Table 4). For both CDs and A-RPDs, perceived competence depended on the number of treatments carried out as the assistant, while for fixed prostheses and M-RPDs (retained by cast clasp or attachments) perceived competence was influenced by acting as both assistant and operator. In addition, there were other qualitative factors that proved to be meaningful predictors of performance. In the case of A-RPDs, a lack of theoretical proficiency reduced significantly (between 0.1 and 1.3) students' perceived clinical competence. The type of teaching method (traditional vs. PBL) also proved to be an influencing factor in perceived level of clinical competence when carrying out A-RPDs, M-RPDs, and fixed prostheses. Students in the traditional cohort perceived themselves as being significantly more competent to carry out treatments involving A-RPDs (0.1-1.1), M-RPDs (0.7-1.6), and fixed prostheses (0.4-1.4). The predictive capacity of the models (R^2) ranged between 0.11 and 0.34; therefore, it was necessary to identify more predictive variables to increase the amount of variance explained (see footnotes to Table 4). According to these models, each student would need to participate as the assistant in treatments involving ten CDs, six A-RPDs, ten RPDs retained by cast clasps, eight fixed prostheses, and ten M-RPDs retained by attachments.

Discussion

The acquisition of clinical competence was the reason for revisions to university study plans (Bologna Process) for teaching odontology, which should be periodically reassessed. Although it is true that the teacher/tutor evaluation influences this assessment in a decisive way, students' self-assessment

Table 4. Results of analysis to predict clinical competence for different methodologies after inclusion of all potential variables (sociodemographic, type of student, and all qualitative and quantitative self-rated performances items)

Prosthodontics Competence	B	Error	Contrast Standardized B	p-value	CI 95% Lower	CI 95% Upper
Complete dentures[a]						
Intersection	7.1	0.1		<0.001	6.8	7.3
Number of complete dentures made as the assistant	0.5	0.2	0.30	0.003	0.2	0.8
Acrylic partial dentures[b]						
Intersection	7.5	0.7		<0.001	6.2	8.8
Number of partial dentures made as the assistant	0.9	0.2	0.39	<0.001	0.5	1.3
Theoretical proficiency (theoretical skill)	-0.7	0.3	-0.22	0.02	-0.1	-1.3
Student type (PBL vs. traditional)	0.6	0.3	0.18	0.04	0.1	1.1
Metal-framed partial dentures[c]						
Intersection	5.9	0.2		<0.001	5.5	6.3
Student type (PBL vs. traditional)	1.2	0.3	0.39	<0.001	0.7	1.6
Number of clasp-retained removable partial dentures made as the operator	0.7	0.2	0.36	<0.001	0.4	1.0
Number of partial dentures made as the assistant	0.4	0.2	0.19	0.02	0.1	0.8
Fixed partial prostheses[d]						
Intersection	6.4	0.2		<0.001	6.0	6.7
Number of FPDs made as the operator	0.8	0.2	0.37	<0.001	0.4	1.2
Student type (PBL vs. traditional)	0.9	0.3	0.31	0.001	0.4	1.4
Removable partial dentures combined with fixed prostheses by attachments[e]						
Intersection	5.6	0.1		<0.001	5.3	5.8
Number of attachment-retained prostheses made as the operator	1.3	0.3	0.42	<0.001	0.8	1.9

[a] $F=9.56$ df=1; $p<0.01$; Corrected $R^2=0.11$
[b] $F=9.5$ df=3; $p<0.01$; Corrected $R^2=0.20$
[c] $F=18.5$ df=3; $p<0.001$; Corrected $R^2=0.34$
[d] $F=17.3$ df=2; $p<0.001$; Corrected $R^2=0.24$
[e] $F=21.9$ df=1; $p<0.001$; Corrected $R^2=0.17$

(as those receiving instruction) is no less important. The students' evaluation of their level of competence and academic performance acts as an indicator of the instruction received and could help redefine how students are taught. The teaching of odontology has been based exclusively on the decisions of heads of department and professors,[15,16] which carries a certain degree of subjectivity. Moreover, since implementation of the new plan in 2010, there has been no evaluation of the effectiveness of the new methodology regarding attainment of competence and students' perceptions of teaching. Keeping in mind that it is difficult to objectify or quantify the effectiveness and performance of the new plan, we believe the information provided by the students is a valuable approach. However, the results obtained for any methodology are influenced by the teacher-student relationship and may not reflect the effectiveness of the particular method.[17] In addition, self-perceived competence does not necessarily reflect actual competence, so other terms such as "confidence" or "preparedness" may be more accurate for describing an individual's self-appraisal of how well prepared he or she is for prosthodontic practice.

In our study, we assessed students' self-perceived clinical competence by means of a survey with a range of 0-10, which is an easy and valid method with which most students are familiar because it is commonly used in university evaluations. This simple method was recently used to measure the preparedness of 525 final-year undergraduate dental students in the UK.[18] One limitation of our study is that its design with two cohorts of students who experienced two different teaching methodologies in different years could not control for other potential effects on student perceptions in individual years. However, for operative and legal reasons, a random application of the two methodologies to students would not have been approved, nor would a parallel or crossover study design. Also, it should be kept in mind that there is inherent variability regarding students' manual skills, cognitive capacity, and motivation within each academic year. This study was conducted in the fourth year with the aim of comparing the effectiveness of the previous and new methodologies in the area of prosthodontics. However, in the fifth year the clinical prosthodontic competencies are further reinforced during the subject "Practicum" (new plan) and "Integrated Dentistry" (old plan), which is more than 90% clinical teaching.

As pointed out by Scott, there is still large variability in the number of credits assigned to prosthodontics across Spanish dental schools (from 18 to 30 ECTS).[19] Furthermore, Brand et al.'s study found considerable variation among ten European dental schools (from Finland, France, Netherlands, Slovenia, Sweden, and the UK) regarding the teaching of fixed prosthodontics, concluding that dental curricula varied in prosthodontics training with regard to the year in which teaching begins (from year 2 to 5) and in the materials and techniques used for fixed prosthodontics, as well as the compulsory number of treatments students must perform before graduating.[20]

Although the new PBL program uses more student-centered learning (more guided work in small teams, more clinical sessions, and the creation of repositories of multimedia contents to be used by learners), manual skills are still acquired during preclinical and clinical practices that have changed very little over the decades. We find it quite likely that the dental degree has long been oriented toward the acquisition of competence for graduates starting their professional careers, ever since its approval as a Spanish university title in 1986 according to the Royal Decree 970/1986 by the Spanish government. In fact, in the fifth year, credits are assigned almost exclusively to teaching of the complete clinical care of various target groups (adult patient, infant patient, patients with special medical situations) and are comprised of subjects traditionally defined as "Integrated Dentistry," which in the new plan is called "Practicum."

Greenwood et al. also compared PBL and traditional methodologies in dental education in terms of self-perceived competence upon graduation and found great similarity between the two.[21] In our study, a significantly higher proportion of the traditionally educated students perceived they were competent to treat patients with FPD (81%) than the PBL students (29%). In addition, Yiu et al. found significant differences between the self-perceived preparedness of graduates of the Hong Kong University Faculty of Dentistry's new PBL curriculum and graduates of the traditional curriculum with respect to nine domains.[22]

In our study, the PBL methodology did not appear to be superior to the traditional methodology; in fact, it seemed that, perhaps due to the lower level of manual skills perceived by the PBL students (Table 1), their perceived level of clinical competence was lower than that of students in the traditional cohort, particularly regarding some treatments that required dental preparations such as metal-based removable partial dentures and especially fixed prostheses.

This finding could be a spurious result based on the specific manual skill of the group of students rather than being attributable to the methodology itself. It may also be due to the fact that the PBL cohort was in the first two years of the new plan, in which the new methodology was implemented in an almost experimental way and the teachers as well as the students had to apply new methods that required previous experience in order to be completely effective.

To date, only two studies have evaluated the effects of PBL on students' manual skills: one on preparing CAD/CAM ceramic inlays[23] and the other on performing nonsurgical periodontal treatment.[24] In both of those studies, no statistically significant differences were found between PBL and traditional methods. Reich et al.'s study also concluded that the PBL students were less satisfied with their performance and the methodology, perhaps due to the greater effort required in self-directed learning without support from traditional lectures.[23] Overall, our study suggests that the key to competence in prosthodontics lies in clinical practice since the number of patients treated was a significant indicator of the level of perceived competence (Table 4), which means that the teaching method was less important since in both programs students' confidence in clinical skills was acquired in the simulation laboratory and on patients.

There is no consensus with respect to the minimum number of treatments needed to acquire basic competence in prosthodontics. In UK dental schools, students are expected to have carried out between one and three complete denture treatments during their studies, with most schools expecting at least three complete denture treatments.[25] In the case of Spanish dental students, this treatment cutoff point would be achievable after having completed the fifth-year course "Integrated Dentistry" since, in our study, half of the students had carried out at least one complete prosthesis as operator and another as the assistant.

Likewise, the average number of FPDs found in our study for fourth-year dental students was greater than that reported by Lynch et al., in which the average number of conventional FPDs performed by undergraduate dental students was 0.27 (range 0-1) for the UK and 0.44 (range 0-1) for Ireland.[16] Hence, it is possible for dental students of these two countries to graduate without any clinical experience with FPDs. By contrast, in Norway, the competency level of dental students with respect to fixed prosthodontics is expected to be high since the number of dental preparations for FPDs increased from nine in the old curriculum to 11 in the new curriculum (implemented in 2000).[26] Even better results were found at the Harvard School of Dental Medicine, where students completed an average of 2.6 RPDs per student, 2.6 CDs per student, and 12.7 FPDs per student.[27] Those figures are higher than the numbers found in our study according to the models of linear regression (Table 4) in which it is inferred that the students perceived maximum competence after carrying out six CDs and three RPDs as the assistant and six M-RPDs and five FPDs as the operator, independently of the remaining modulating variables.

In addition, both cohorts of students in our study recognized the fact that there is a great deal of difference between preclinical practical training using typodonts and the care of real-life patients. Curtis et al. did not find a correlation between preparations involving complete crowns carried out on typodonts and those using real patients.[28] However, Velayo et al. found a positive and significant correlation between preclinical and clinical performance for operative dentistry and fixed prosthodontics.[29]

In our study, 33-40% of the students would like an increased number of clinical sessions and 49-54% would like increased practical training to increase their level of prosthodontic competence (Table 2). It is also worth noting that both cohorts of students identified a weakness in oral expression, despite having practiced during other clinical discussions with groups of graduating students. Perhaps it might be advisable to increase the teaching effort in this area since oral expression is a transversal competence that should be applied in other subjects throughout the degree course and in different settings in order to be acquired.[30]

In our study, the majority of the students had a positive perception of their teaching experiences, but Barrero et al. concluded there was a need to improve practical training in the laboratory and the clinical sessions to properly prepare students for prosthodontic practice.[14] In fact, only two-thirds of the respondents in that study considered that the preclinical fixed prosthodontics courses were helpful for diagnosing and treating patients.

Similarly, at Harvard School of Dental Medicine, which also uses hybrid PBL, the majority of students reported feeling they had not acquired enough knowledge from the lectures, and the majority did not feel confident in treating prosthodontics patients in the clinic.[27] However, in our study, the majority of the students considered that they had received the appropriate amount of theoretical teaching to be

able to carry out clinical practice, and the majority felt confident to do so (Table 1). Most probably the difference is due to the fact that the Harvard prosthodontics curriculum is taught mainly during the first six months of the third year, which is when students learn about FPs, RPDs, CDs, dental materials, and implant dentistry. Our fourth-year students had received more in-class hours with additional time to acquire knowledge and manual skills. Recently, at Harvard, the newer flipped classroom approach has been introduced for teaching anatomy to second-year dental students, obtaining great acceptance among students and faculty members.[31] The flipped classroom is a blended learning model in which students access foundational contents online before class time, take a pre-class quiz, and then participate in group discussions and collaborative activities during class.

There are probably many valid and effective models for building competence in prosthodontics. If we used the clinical competence data regarding the fixed partial dentures as a proxy of the students' global rating of their fixed prosthodontics education, using a 0-10 range, our results (6.6±1.5 for PBL students; 7.6±1.1 for traditional students) were within the average range of 5.6±2.2 reported by students at Ljubljana University (Slovenia) to 8.0±1.1 found among students at Nijmegen University (Netherlands) reported by Brand et al.[20] Moreover, we did not find any significant differences regarding gender, which is in agreement with Walley et al.'s findings.[18]

At our institution, the main advantage of PBL is that teachers have more control over the students' strengths and weaknesses. Also, the weekly small group tutorials and interactive seminars provide for continuous evaluation of students' learning process and allow the student-teacher relationship to improve. Furthermore, the introduction of PBL has been a means for teachers to refine and update their course content. Each year we are able to optimize the methodology used, learning more about the effectiveness of such teaching strategies as role playing and clinical sessions of pathognomonic cases for specific subject matter. Nevertheless, PBL requires greater effort on the part of the student in the attempt to accumulate knowledge and skills, without the presence of a clear guide of what to do, given that PBL promotes self-directed learning. Perhaps this is the reason why the students were more doubtful about their own level of theoretical knowledge and also because they were aware of the large quantity of available information and the divergent facts presented in the literature. It may be better to give both teachers and students more structured approaches on which to base their teaching and learning.

Conclusion

In our study, the level of competence perceived by students educated using traditional methodology was significantly higher than those in the new PBL program in the treatment of removable partial dentures and fixed prostheses. However, overall, we found that students' practical experiences were more important than the teaching method used in improving their perceived competence in prosthodontics.

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Disclosure

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