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Impact of problem-based learning on knowledge acquisition and satisfaction among undergraduate students at the faculty of medicine and pharmacy of Fez Experimental study

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Abstract

Background: In Moroccan medical schools, several teachers and students complain about the limits of transmissive education. The problem-based learning (PBL) has been introduced in many medical schools around the world but not yet in Moroccan medical schools.

Aim: The aim of this work is to experience PBL in basic medical training at the Faculty of Medicine and Pharmacy of Fez; and assess its impact on student satisfaction and short-term performance.

Materials and methods: in 52 participating students, we compared the acquisition of knowledge by the PBL versus transmissive teaching. We also used a questionnaire to assess their level of satisfaction with PBL.

Results: Compared to formal education, students reported better satisfaction with PBL, regarding their motivation, level of concentration and understanding; but also on the development of "*soft skills*": Communication, cooperation in the group and autonomy. The knowledge assessment test objectified that the average score of the groups (out of 10) is respectively 7.9 and 7.63 for PBL versus 4.88 and 4.08 for transmissive teaching (p = 0.0001).

Conclusion: Our results confirm the advantages reported in the literature of PBL over conventional education and have motivated the partial implementation of this method in our faculty.

Keywords: Problem-Based Learning; Teaching; Pedagogy; Evaluation; Satisfaction

1. Introduction

1.1. Problems arising from conventional teaching

Traditional university teaching has been based on transmissive teaching, which focuses on the knowledge that the professor teaches in a lecture. The underlying assumption of this pedagogy is that if the content is clearly stated, then the student understands what is being taught. The strength of this pedagogy would be its speed, making it applicable to a large audience, and requiring few hours of teacher supervision. But is transmissive teaching enough to a correct understanding and assimilation? If that were the case, shouldn't the success rate be close to 100%? Unfortunately, this is not the case. Many teachers are not satisfied and are asking: Why do our students lack motivation? Why do their results sometimes fall short? And, above all, why the concepts that should have been acquired in previous years aren't

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assimilated ? (1). They note that the skills acquired by students are not of a high level, and they only know how to restitute and -in the best case- apply (2) .

Medical curricula in Morocco, as in some other countries, are based on the principle of acquiring a theoretical grounding as a prerequisite for practical teaching. However, many teachers of clinical subjects regularly express their dissatisfaction with students' difficulties in mobilizing their theoretical knowledge, acquired in the early years of the course, to solve specific clinical situations. Indeed, studies in cognitive psychology have shown that when theory teaching is detached from any concrete reference:

- It leads, In the long run to fatigue and demotivation on the part of most students, due to a lack of understanding of the usefulness of the teaching content, especially if the essentials have not been explained and justified;
- It relies on semantic memory, neglecting episodic and emotional memory. As knowledge is not integrated due to the compartmentalization of disciplines, it will be difficult to reuse it later (3).

Transmissive teaching does not encourage the use of strategies for in-depth learning (3). Cognitive strategies include memorization and repetition. In terms of strategies of support information processing, students have little affective involvement, take few metacognitive actions, and make minimal use of the resources available to them. They perform a task imposed by the teacher, but without investing themselves in learning. Many students report that they are more concerned with short-term exam performance than longer-term knowledge integration. These strategies encourage the erosion of knowledge once the exams are over (1).

Another problem is that the body of medical knowledge is constantly growing. This means reinventing a way of looking at things, in preparation for "not knowing what's going to happen". Training a doctor is not just about imparting knowledge, but also about developing personal and professional skills. With this in mind, the Royal College of Physicians and Surgeons of Canada has established the CanMEDS benchmark for training a seven-star doctor. In addition to medico-technical expertise, a doctor should ideally be a collaborator, manager, scholar, ethicist, health promoter and communicator (4). Yet conventional education does not seem to prepare future doctors for all these functions.

It's clear that the "traditional" university teaching model, with its emphasis on lectures, no longer seems to correspond to the professionalism demanded by society (5) and desired by the heads of certain faculties of medicine, pharmacy and dentistry in Morocco.

To overcome the fragmentation of knowledge and the difficulties involved in mobilizing it to solve health problems, the competency-based approach has emerged in medical pedagogy (6). Problem-based learning (PBL) is part of this approach. It is a highly structured educational method, organized in three stages over a short period of time (one to two weeks). It alternates between group work and individual learning. Prior to any theoretical intervention by the teacher, PBL enables small groups of students to familiarize with a problem-situation, understand its particularities and, ultimately, attempt to explain and/or solve it (7).

1.2. The challenges of implementing problem-based learning in Morocco

In Morocco, the question of changing teaching practices is currently at the heart of the debate. The aim is to devise appropriate teaching methods for a new generation of students requiring special attention. Indeed, during the 2018-2019 academic year, a historic strike movement had shaken Moroccan faculties of medicine and pharmacy. Pedagogical demands were at the forefront. Yet the national reform of medical studies, favorable to change and innovation in teaching methods had just come into force since the 2015-2016 academic year. One obstacle among others is that Moroccan medical teachers' knowledge of the competency-based approach is heterogeneous. A study conducted at the Faculty of Medicine and Pharmacy in Marrakech found that 12% of respondents had no knowledge of this approach, while 24% attached it to knowledge alone (8).

Since its uncertain beginnings in the mid-1960s at McMaster University Medical School in Canada, PBL has become relatively commonplace in several European, North American and Asian medical schools (9). Among the reasons that motivated these medical schools to introduce PBL, the effect of medical school accreditation was one of the main causes. In these universities, the rate of use of non-lecture-based learning modalities in the medical curriculum was chosen as an evaluation criterion for medical school accreditation. To meet these criteria, most Asian schools have adopted a "hybrid" PBL + lecture program as their policy (10). As it turns out, the Faculty of Medicine, Pharmacy and Dentistry in Fez (FMPDF) has recently taken steps towards accreditation by a national body and program evaluation by the “Conférence internationale des doyens des facultés de médecine d'expression française” (CIDMEF). The medical training it provides should now be in line with international standards (11) . However, lectures are still the only method of

teaching. Many professors resist change, preferring to continue "talking to students alone", and are reluctant to introduce pedagogical innovations into the curriculum. And as elsewhere, they are concerned about a potential decline in disciplinary level (12). In the Moroccan context, the question of the effectiveness of these pedagogical methods compared to a traditional course still arises. In a study carried out at the Faculty of Medicine and Pharmacy in Marrakech, almost half the participating teachers felt that the competency-based approach was not applicable to their faculty, and 17% of them felt unprepared to adopt it. Some reluctance persists, and may be linked to a fear of radical change within the institution. Participants also stressed the importance of preserving the lecture format (8).

In order to create the conditions for successful pedagogical change, it is important to anticipate resistance to change, and to prove that the change will bring success by implementing an action-research approach (13). Our work is part of this approach. It examines the effectiveness of PBL and its acceptability by students, in comparison to conventional teaching, through a one-off experiment in a health sciences curriculum, and particularly in the first year of medical studies, involving students who are not used to active learning methods. The results obtained should enable us to highlight the strengths and limitations of PBL in basic medical training, and thus contribute to current discussions on improving the quality of training.

2. Materials and methods

This is a randomized experimental study comparing the PBL method with conventional teaching (figure 1).

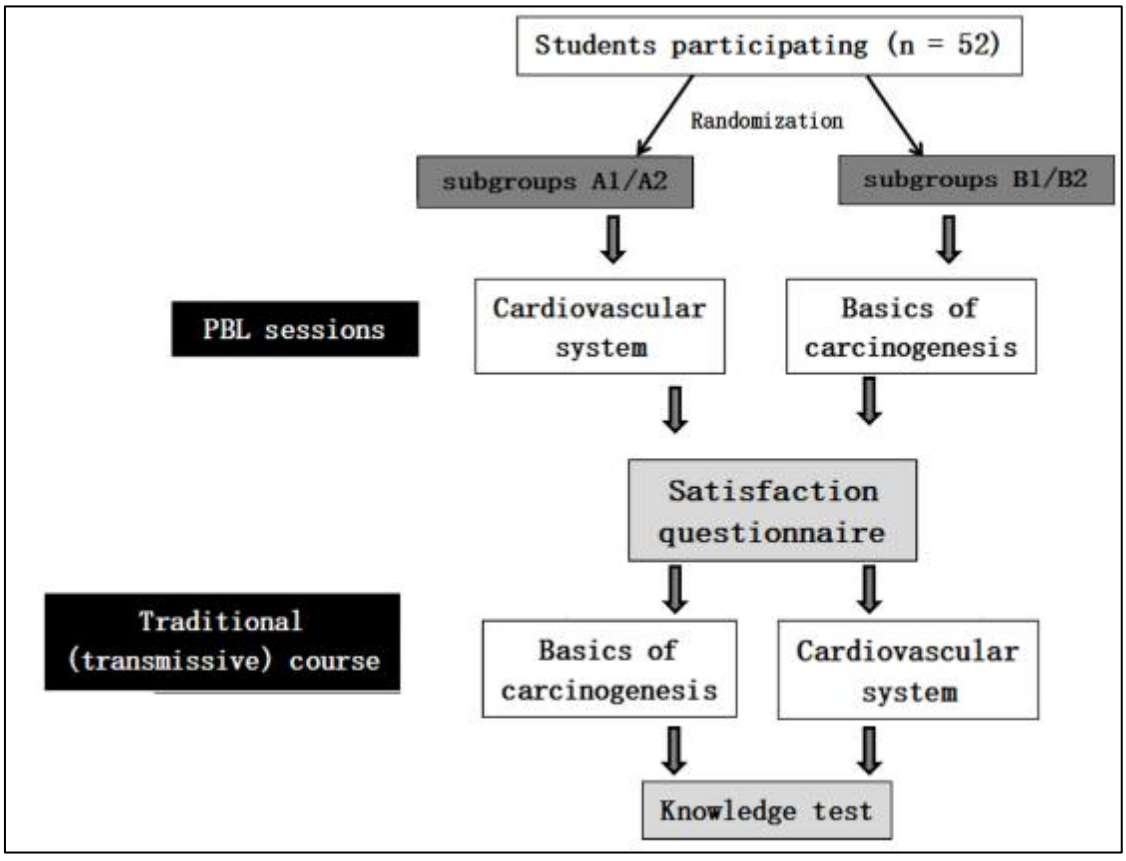

Figure 1 The flow diagram of the study.

2.1. Inclusion of participants

The study began with a call for participation addressed to non-repeating students enrolled in the first semester of the first year of medical school. Fifty-two students initially volunteered to take part. They were randomly divided into two groups, A and B, of 26 students each. A WhatsApp group was set up to facilitate communication and to send students documents explaining the study protocol and presenting the steps of the PBL method (14).

For the purposes of the method (small-group learning), each group was subdivided into two sub-groups, each including 13 students.

2.2. Experimenting with problem-based learning:

These steps were adapted from those of the Sherbrook Faculty of Medicine (15) . They were spread over two sessions, separated by a one-week period of individual research work.

2.2.1. The "Go" session

Students and tutor worked around a U-shaped table in a small room with a large blackboard. To ensure that the students benefited fully from this experiment, the teacher-tutor took on the role of facilitator and secretary (16)

Two realistic clinical situations were drawn up in advance, corresponding to areas in which the students had no prior knowledge, but which they might encounter frequently in their future practice. These were a clinical case on myocardial infarction presented to sub-groups A1 and A2, while another clinical case on cervical cancer was presented to subgroups B1 and B2 on paper.

- Step 1: Clarify terms and data in the problem statement
- Step 2: Define the problem and list the elements and phenomena to be explained.
- Step 3: Propose explanatory hypotheses
- Step 4: organize proposed explanations
- Step 5: Formulate learning objectives

2.2.2. Individual study (Step 6)

Each student has one week to apply the instructions given by the teacher at the end of the "Go" session:

- Identify the most appropriate sources of information
- Reject irrelevant material and highlight what's important by underlining, rephrasing or summarizing as required;
- Record points of ambiguity for group discussion during the debriefing session;
- Summarize new acquisitions in the form of an individual concept map, known as a "naïve" map because it may naturally contain links or inaccurate or incomplete notions (17).

2.2.3. The return session (Step 7)

The group of students explained the problem, pooling their acquired knowledge. The discussion ended with the construction of a collective synthetic concept map (17).

2.3. Subjective assessment of student satisfaction

At the end of the PBL return session, each student was asked to answer an anonymous 16-question questionnaire. Each statement in the first 12 questions was rated on a Likert-type scale, ranging from 5 points for "Perfectly agree", to 1 point for "Totally disagree", comparing the PBL method tested with the conventional teaching method (lecture).

2.4. Transmissive teaching

This was carried out one week after the PBL return session. During this 2nd phase of the study, we switched themes in the 2 groups:

- Group A received a course on the fundamentals of carcinogenesis.
- Conversely, group B received a course on atherosclerosis.

The two courses were given by two different teachers. The teachers used a PowerPoint presentation as a teaching aid. The duration of the transmissive course was three hours, equivalent to the sum of the duration of the "go" and "return" sessions of the PBL.

2.5. Objective knowledge assessment test

The test was organized three days after the end of the course. Students had no support to prepare themselves. All students in both groups took part in the test, which lasted 40 minutes. The test consisted of a part assessing fundamental knowledge in relation to vascular pathology, marked out of 10 points. The 2nd part, also out of 10 points, assessed fundamental knowledge of carcinogenesis.

2.6. Statistical analysis

Quantitative variables are presented as mean ± standard deviation. Comparisons between the two groups are made using the chi-square test for qualitative variables and Student's t test for quantitative variables.

A p-value was considered significant if < 0.05. Statistical analyses were performed using Epi Info software.

3. Results

Four students in group A and eight students in group B were unable to complete the experiment.

3.1. Students' subjective assessments

Student satisfaction was higher with the PBL method than with lectures, with a significant difference ($p < 0.01$) for all items studied: motivation, concentration, comprehension, communication, cooperation, teamwork and autonomy (Table I).

Table 1 Comparison of the degree of satisfaction expressed by students between PBL and lectures.

	PBL		**Lectures**		
	Average score	Standard deviation	Average score	Standard deviation	p
Motivation	4.95	0.22	1.77	0.42	<0.05
Concentration	4.85	0.36	2.4	0.59	<0.05
Understanding the course	4.75	0.49	2.57	0.67	<0.05
Communication	4.95	0.22	1.02	0.15	<0.05
Cooperation and teamwork	4.57	0.5	1.92	0.26	<0.05
Autonomy	4.35	0.48	2.37	0.49	<0.05

In addition, the vast majority of students appreciated the use of a clinical situation, expressing that it had a beneficial impact in achieving learning objectives (Figure 2).

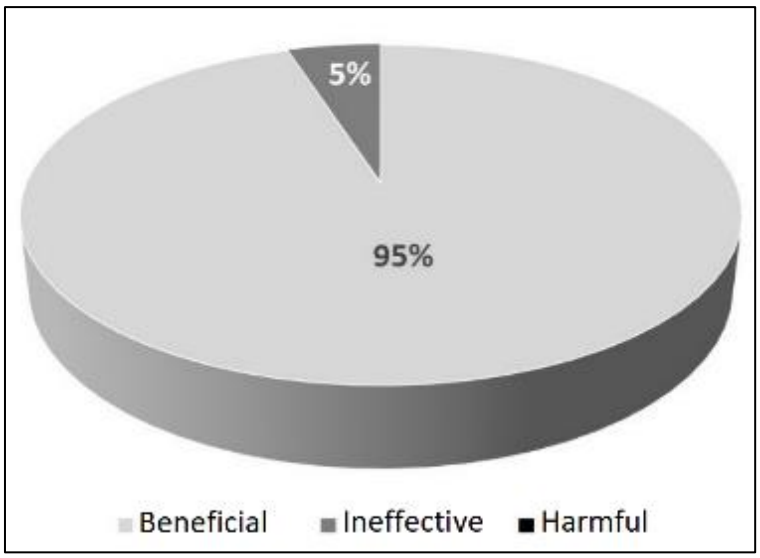

Figure 2 Distribution of students' opinions on the impact of using a clinical situation on the achievement of learning objectives

Concerning the tutor's main style in leading the sub-group. The majority of students felt that the professor mainly regulated discussion and interaction between students during the "go" session, and that he mainly interacted directly with each student during the "return" session (Figure 3).

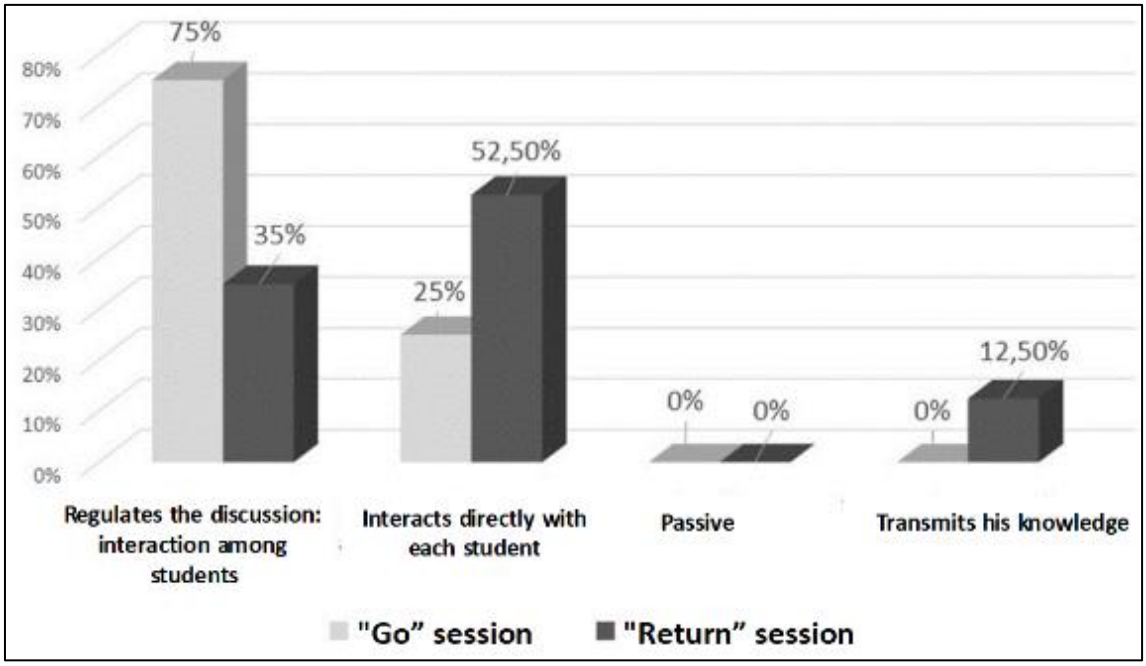

Figure 3 Distribution of students' assessments of the professor's main style in leading the sub-group

3.2. Objective assessment by test

The PBL showed its superiority in terms of students' knowledge assessment results for the two themes taught, with a significant difference (Tables 2 and 3).

Table 2 Comparison of the degree of satisfaction expressed by students between PBL and lectures.

Group	Pedagogical format	Group evaluation average	Standard deviation	p
A	PBL	7.9	0.88	0.00001
B	Transmissive	4.89	1.09	

Table 3 Comparison of the average score of the 2 groups for the "basic knowledge of cancer pathology" theme.

Group	Pedagogical format	Group evaluation average	Standard deviation	p
A	Transmissive	4.08	0.97	0.00001
B	PBL	7,64	0,99	

4. Discussion

Various studies on the outcomes of PBL programs have shown a clear trend towards higher acquisition of clinical performance by PBL graduates (18) (19). PBL graduates do better in faculty evaluations and clinical examinations (20). The PBL method has proven to be an effective pedagogical tool for fostering critical thinking, problem-solving and decision-making skills (21). Nevertheless, one study compared the level of knowledge and skills of medical students between PBL and "traditional" curricula, and found no significant differences on short-term tests of factual knowledge between the two systems. On the other hand, the teaching situations organized around the PBL develop the acquisition of skills. PBL is conducive to understanding the content studied and developing the ability to apply new knowledge. It has the advantage over traditional teaching in terms of knowledge and skills development (21). What's more, PBL

reduces the disparity between students with unequal initial knowledge. It enables students with no prior knowledge to make better progress than those in the conventional group, as it uses learning modalities based on learner autonomy and self-assessment (22).

In our study, the assessment explored the level of knowledge acquisition. It showed a clear superiority of PBL over transmissive teaching. This could be explained by better concentration and comprehension of topics with the PBL method. Our results tend to show that the PBL system is effective, even for students who are not used to being active.

So how can we explain the PBL's good performance?

- Consistency of the PBL method with the principles of active pedagogy

PBL is consistent with the socio-constructivist approach, which emphasizes the importance of preconceptions and interaction with peers in learning (23). PBL encourages a form of student-centered learning in which students participate dynamically in their own training, and promotes habits of active lifelong learning (24).

- The impact of PBL on student satisfaction

Students' views on the transition to PBL are interesting. PBL is a more enjoyable form of learning, with a higher degree of satisfaction than traditional teaching methods. Students point to better assimilation of the material (20).

- The impact of PBL on teachers' and students' attitudes to knowledge

Students' attitudes to knowledge must shift from a naïve representation of knowledge (true/false), in which it is the teacher who transmits the truth, to a representation that enables them to judge the value of knowledge with moral commitment and relativity, depending on the context in which it is used. Teacher-tutors perceive the training offered to students through the PBL method as a factor favoring this evolution of intellectual posture in students, leading them to become professionals capable of dealing flexibly with the situations they will be confronted with (25)

- The impact of PBL on the integration and contextualization of knowledge

The PBL is one of the teaching methods that breaks with the juxtaposition of theoretical and practical training. It reduces the compartmentalization of both pre-clinical and clinical disciplines, through integrative interdisciplinary systems. Basic medical sciences are learned in parallel, and always in the background of a clinical situation (21). The networked integration of related concepts across different memory systems strengthens the acquisition of each. (26). The student perceives that the learning activity proposed is useful for him. In our study, the use of simple clinical cases was widely appreciated by students, as 95% of them considered it beneficial for their learning.

- The impact of PBL on reasoning

PBL supports the development of hypothetico-deductive reasoning. The student becomes more precise when formulating a hypothesis, more adept at using his or her knowledge in real time, and solves complex problems in a less simplistic way (21). Later, when this student becomes a practitioner and is confronted with a new case involving elements he or she has never encountered before, the schema that includes the most concordant elements will be activated and identified, then adapted to the new situation encountered (27).

- The impact of PBL on students' learning strategies
    - Cognitive strategies

Research has established a link between the PBL method and more complex learning strategies such as knowledge organization and elaboration (28). Students use more in-depth information processing strategies than students in traditional cohorts (29).

These data from the literature were confirmed in our study, since the students who took part said that PBL helped them to concentrate and understand content better than transmissive teaching.

    - Affective strategies

In PBL, students feel responsible for what they have to learn. The majority of students report that their curiosity and personal commitment help them to maintain their intrinsic interest and concentration when working in groups to accomplish their learning (30). Our study confirms this finding, with students reporting that they were more motivated to learn in a PBL than in an amphitheater.

- Management strategies

In PBL, almost all students are punctual, make greater use of material resources, start their work in advance and refer to colleagues when difficulties arise. Working in small groups protects against dropping out and encourages students to study regularly (29) .

- Metacognitive strategies

Students evaluate their work on the basis of their own judgement of how they learn. Faced with cognitive difficulties, they wish to become more involved in group work and increase study time during individual work (29).

- The impact of PBL on the acquisition of *soft skills*

As an interactive teaching method, PBL has the added advantage of conferring skills such as *leadership* and delegation, all of which are sought-after qualities in the medical profession. It has been found to improve student-student relations and introduce the concept of teamwork. The use of PBL helps develop the skills of active listening and empathy (14). PBL promotes group communication and collaboration (31).

The students participating in our study agree with these findings, declaring that PBL is better than lectures for developing their communication, autonomy and teamwork skills.

The good results obtained in our experiment can be partly explained by the tutoring style mainly used by the teacher during PBL sessions. Indeed, Vierset et al have categorized four styles: active, transmissive, incentive and permissive. Each style can be defined on the basis of the different types of "interactions" that can be observed between the teacher and the students who make up a class (16). In our study, the students felt that the tutor had mostly used an active style during the "Go" session (75%). In contrast, during the "Return" session, this style was used less, giving way to incentive (52.5%) and transmissive (12.5%) styles. A number of studies have established that tutors who favor open-ended questioning, in line with an active style, by requiring in-depth reasoning, rather than the use of more or less closed questions (incentive style) or "lecture capsules" (transmissive style), are more conducive to the development of problem-solving and thinking skills (32). Note that the difference in facilitation style between the two PBL sessions described by the students in our study was previously described by Lison et al (33) , who reported in their study that the active style was also in the majority on the go journey, whereas it was used less than half the time on the return journey. This difference between "going" and "returning" could be considered predictable, since "going" is mainly used to reactivate prior knowledge and propose hypotheses to solve the problem. The "return", on the other hand, involves the synthesis and validation of knowledge and solutions related to the problem. So, to ensure that all the important points are covered during the return, tutors are more likely to ask questions and provide information, implying the adoption of more incentive and transmissive styles. Consequently, the teacher-tutor needs to be vigilant to this change, as it could lead students to become less involved in the "return" stages of the session and let the tutor take over the reins, thus becoming more passive and reverting to the traditional teaching paradigm (33)

4.1. Study limitations

Our study involved a limited number of students. Participation on a voluntary basis could be a bias, as these were people motivated to live a new experience. Moreover, the high degree of satisfaction expressed by the students in all items during this experiment could be explained by the fact that the novelty of the process could itself have been a source of motivation for the students.

Furthermore, the evaluation used in this study assessed short-term knowledge acquisition following a single PBL sequence. We are aware that the data obtained in this initial research are not sufficient to formally conclude the positive effects of PBL on the acquisition of medical skills. We intend to continue this work in the long term, with a larger number of students.

5. Conclusion

The results of our experiment, which cannot be generalized, notably because of the relatively small number of students involved, are in line with numerous research studies highlighting the effectiveness of PBL teaching in terms of knowledge acquisition and the satisfaction of students who are not used to active learning.

A university environment can benefit from several complementary pedagogies. PBL and traditional learning could coexist and enhance the learning experience. Moroccan faculties of medicine and pharmacy will find it easier to identify the development paths best suited to their environment and the constraints they face. The key is to clearly identify the aims of the training, the most appropriate means of achieving them, the proposed evaluation and the feasibility of the project within our cultural and institutional context. Based on the positive results of our study, the FMPF has partially implemented the PBL method from the 2020-2021 academic year.

Compliance with ethical standards

Disclosure of conflict of interest

Authors don't have financial or non-financial interests to disclose.

Statement of informed consent

All volunteers' students were informed, and gave their informer consent to participate to this study.

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