International Journal of Medical Informatics (2006) **75**, 396—402

ELSEVIER

International Journal of Medical Informatics

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Problem-based learning in medical informatics for undergraduate medical students: An experiment in two medical schools

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Received 17 March 2004; received in revised form 12 July 2005; accepted 13 July 2005

KEYWORDS
Education;
Medical;
Undergraduate;
Problem-based learning;
Evaluation studies;
Internet;
Students;
Medical;
Teaching

Summary
Purpose: The objective of this work was to assess problem-based learning (PBL) as a method for teaching information and communication technology in medical informatics (MI) courses. A study was conducted in the Schools of Medicine of Rennes and Rouen (France) with third-year medical students.
Methods: The ''PBL-in-MI'' sessions included a first tutorial group meeting, then personal work, followed by a second tutorial group meeting. A problem that simulated practice and was focused on information technology was discussed. In Rouen, the students were familiar with PBL, and they enrolled on a voluntary basis, while in Rennes, the students were first-ever participants in PBL courses, and the program was mandatory. One hundred and seventy-seven students participated in the PBL-in-MI sessions and were given a questionnaire in order to evaluate qualitatively the sessions.
Results and discussion: The response rate was 92.1%. The overall opinion of the students was good. 69.8% responded positively to the program. In Rouen, where the students participated in PBL-in-MI sessions on a voluntary basis, the students were significantly more enthusiastic about PBL-in-MI. Moreover, attitudes and opinions of students are plausibly related to differences in previous PBL skills. The fact that the naïve group had two tutors, one trained and one naïve as the students, has been investigated. Teacher naivety was an explanatory factor for the differences between Rennes and Rouen.

1. Introduction

As in many other schools of medicine, the medical curriculum in the Universities of Rennes and

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doi:10.1016/j.ijmedinf.2005.07.014

Rouen (France) has changed with the adoption of the student centered and case-based learning paradigms. In the problem-based learning (PBL) approach, learning takes place in small tutorial groups [1—4]. Learners are given case scenarios to trigger their own learning objectives. For example, from a case history of asthenia, they must single out their own objectives, including objectives on relevant basic sciences, diagnosis, and management, and they are required to find out their own answers following a discussion with the group [5].

The place of medical informatics in the medical curriculum has also changed [6]. Because the role of information and communication technologies (ICT) in the creation and distribution of medical knowledge as well as in patient care is becoming more and more important, introductory knowledge in medical informatics must be provided in all undergraduate curricula [7,8]. It must lead to a health care professional qualification, in compliance with the recommendations that were established by the IMIA's Working Group 1 on Health and Medical Informatics Education (IMIA WG1) [9,10].

Some authors have applied PBL methods to teaching medical informatics. For example, Hasman and Boshuizen use a PBL-like approach for medical informatics topics such as ''Dr. Brown observes her assistant busy preparing patient bills and thinks it would be nice to have a program that could do this task'' [11]. A PBL approach has also been introduced into a health informatics curriculum by Green et al. [12]. The topic of a problem being, for example, ''a data dictionary for an electronic patient record in a sports medical clinic''. In this article, we present an experiment that uses PBL methods to provide third-year medical students with education in ICT. Topics to be covered in that track include information retrieval, quality of information [13,14], as well as consumer health information (e.g., [15,16]). This study was conducted in two schools of medicine in France, namely at the University of Rennes and at the University of Rouen. While all third-year students had prior experience with the use of computers and basic knowledge in computer science, their competency in PBL was quite different:

- In Rouen, PBL has been introduced in the second and the third years of the medical curriculum since 1993. For these 2 years, PBL is the core of the curriculum for teaching basic sciences.
- In Rennes, PBL is introduced in the fourth year of the medical curriculum. Therefore, third-year students are not familiar with self-directed problem-based learning. Traditional discipline-based education is the main form of instruction for first-, second-, and third-year students. Although the PBL approach is not adopted before the fourth year, small-group tutorials complement the conventional lectures in many disciplines.

Table 1 PBL ''technological case''

The reason why Ms. Martin is visiting Dr. Dupont, her family doctor, is that she has to be vaccinated against influenza. During the consultation, Dr. Dupont notices that Ms. Martin is looking very anxious. The reason why she looks so worried is that her brother has just been diagnosed with Friedreich's ataxia. Ms. Martin feels anxious about several points: what will be the evolution of her brother's condition, what is the treatment, is there any consequence for herself and her children? Ms Martin's son has searched for information in the internet and he has found 3200 websites and documents. Ms. Martin has brought the documents that her son has selected and printed out. Dr. Dupont does not have enough time to read them all, and he tells her that the quality of information collected from the internet is ''not so good''. In order to reassure her, Dr Dupont asks her to come back a few days later. He is going to search for information in the internet to be able to answer all her questions

The objective of this study was to evaluate globally the students' perception and the role played by factors, such as naivety in PBL.

2. Methods

2.1. The PBL case in medical informatics

The third-year medical students participated in one PBL case in medical informatics (PBL-in-MI) over the course of the academic year. The students were clustered into small groups of 8—10 students. The PBL-in-MI course was scheduled over 6 h and consisted of (1) a first tutorial group meeting, then (2) personal work, and (3) a second tutorial group meeting.

During the first tutorial group meeting, as in standard PBL, a problem is discussed. The problem simulates practice. It is formulated as shown in Table 1. To achieve the levels of knowledge and skills in information technology as expected for information technology users, specific learning objectives have been specified for the tutors who can then check whether the learning objectives formulated by the students are complete. For example, one objective is: ''students must know the con-

Table 2 PBL teaching objectives

Objectives
Give a precise definition of the topics on which you are searching for information, e.g., disease description, prognosis, evolution, treatment, and biological mechanisms involved
Define the concepts of resource, site, document, web page
List and categorize the tools that are available: search engines, specialized search engines, portals and catalogs, sites that produce information
Describe and explain how these tools work (data vs. metadata, automatic vs. manual indexing, thesaurus vs. natural language, database vs. web pages)
Define precision and recall in information retrieval and apply it
Explore and test decision support systems accessible on the internet and provide comments
Categorize resources according to their purposes and their targets (educational resources, professional, research, consumer health)
Categorize resources according to the editor (universities, patient associations, US National Library of Medicine, etc.)
Clarify the notion of URL, domain name and use them as a criterion for resource categorization (.com, .edu, .gov, .fr, .org, etc.)
Formulate problems about the quality of information in the internet
Enumerate the 10 more important quality criteria
Apply quality criteria to a given internet resource
Build strategies for collecting relevant information via the internet
Evaluate the documents that are accessible on the web and compare them to reference (paper textbooks, etc.)

cepts of precision and recall, and how information retrieval can be improved''. The list of objectives for this task is given in Table 2. It is used as an aide-memoire for the teacher and is given to the students after the session. After that, one-half of the student group is asked to search for information from the patient's point of view (in our example, Ms. Martin) while the other students do the same work from the doctor's point of view (in our example, Dr. Dupont).

During the second phase, students work independently to pursue their goals, either at home or at the computer laboratory. Students are asked to create a Hypertext file that summarizes their work, to include the URLs that they have explored, and to provide comments about their search. No help is provided during that phase except technical support.

During the second tutorial group meeting, as in standard PBL, each student reports back. The main difference with a regular PBL is the use of a microcomputer and a video-projector. Then, the students join forces once more to synthesize their findings.

2.2. Evaluation

An evaluation was performed in 2003. Each student that participated in PBL-in-MI was given a questionnaire at the end of the second tutorial group meeting in order to evaluate the program. The questionnaire consisted of two sections. The first section was related to PBL (Table 3), with regard to:

- The schedule, e.g., was time sufficient or not?
- The content, e.g., how far was the case appropriate to define student's objectives during the first tutorial meeting, and to make a meaningful synthesis at the end.
- Group functioning and interactions.

Table 3 Evaluation of the PBL-in-MI program

	Global		Rennes	Rouen	Comparison Rennes vs. Rouen
	# Answers	% Positive	% Positive	% Positive	
Program					
In the first meeting, it was possible to do all the steps within 1 h	160	80.1	70.5	93.8	$p < 0.05$
The case allowed to define clear objectives	155	69.1	58.9	83.1	$p < 0.05$
In the second meeting, it was possible to do all the steps within 1.5 h	150	82	71.7	95.4	$p < 0.05$
The case allowed for a clear synthesis of the problem	148	65.6	65.1	66.1	ns
Group					
The group functioning was good	148	75.6	72.3	80	ns
The tutor played his/her role well	141	83.7	77.5	91.8	$p < 0.05$
Global perception					
My global judgment on the PLB-in-MI course is good	156	69.8	53.9	92.3	$p < 0.001$
I plan to use ICT to access teaching resources during my medical curriculum	159	74.8	68.5	84.4	$p < 0.05$

The second part of the questionnaire was focused on the role of ICT in the medical curriculum. In addition, the students were asked to rate the teaching methods (conventional lectures versus PBL), and the type of resources (paper versus electronic documents).

A descriptive statistical analysis was performed. We also performed cross tables analysis between variables and we used Pearson Chi-square to test whether there were significant differences between Rennes and Rouen, and McNemar test to compare related dichotomous variables. Statistical significance was declared if a two-sided *p*-value was less than 0.05. All computations were done with the SPSS program Version 10.

3. Results

The total number of third-year medical students was 220, respectively, 112 students in Rennes and 108 students in Rouen. In Rennes, where the PBL-in-MI course was compulsory, all the third-year medical students (100%) participated in PBL-in-MI. In Rouen, where students enrolled on a voluntary basis, 65 students (60% of the third-year students) participated in PBL-in-MI. Of the 177 third-year medical students that participated in PBL-in-MI, 163 students (92.1%) completed the questionnaire, 98 in Rennes (87.5%), and 65 in Rouen (100.0%).

69.8% of the students, who participated in the experiment rated it highly. The proportion was different in Rennes (53.9%) and in Rouen (92.3%) ($p < 0.001$).

The students' opinion was that the group functioning was good (75.6%), with no significant difference between the two Universities. They also reported that the tutor played his/her role well (83.7%). However, there was a significant difference ($p < 0.05$) between Rennes where 77.5% of the students answered positively to that question and Rouen where 91.8% answered positively. When the students were asked whether the objectives were clearly defined, 69.1% answered positively in overall, but only 58.9 % in Rennes versus 83.1% in Rouen ($p = 0.005$).

Within the naïve group of students (Rennes), we compared the results corresponding to the naïve tutor to those of the trained tutor. No significant difference was found, except for two questions. For these two questions, namely ''the group functioning was good'' and ''my global judgment on the PBL-in-MI is good'', students' opinions were significantly better with the naïve tutor.

74.8% of the students mentioned that they intended to use ICT to access teaching resources for the rest of their curricula. An evaluation of elec-

Table 4 Evaluation of paper documents vs. electronic resources

Resource (McNemar test $p < 0.001$)	Electronic resources	
	Positive opinion	Negative opinion
Paper documents		
Positive opinion	48	74
Negative opinion	2	39

Table 5 Cross tabulation between PBL and academic courses

PBL	Academic courses	
	Positive opinion	Negative opinion
Global results (McNemar test $p < 0.001$)		
Positive opinion	44	80
Negative opinion	24	7
Rennes (McNemar test $p < 0.05$)		
Positive opinion	25	40
Negative opinion	19	6
Rouen (McNemar test $p < 0.001$)		
Positive opinion	19	40
Negative opinion	5	1

tronic documents versus paper documents was also performed showing that students' preference was given to paper documents (Table 4).

The questionnaire was also used to evaluate PBL versus academic courses. In Rouen, the results showed significantly higher scores for PBL than for academic courses (McNemar test $p < 0.0001$). Among the 65 students (100% of the students) who answered that question, 59 (91%) found PBL satisfactory or very satisfactory, and 24 (37%) found academic courses satisfactory or very satisfactory (Table 5).

4. Discussion

The opinion of the students that enrolled in this program was globally good since 69.8% responded positively. However, a more detailed analysis shows real difference between the two schools of medicine that participated in this study. It must be highlighted again that the context was different: while in Rouen, the students were familiar with PBL, in Rennes they were not; while in Rouen, the third-year medical students enrolled on a voluntary basis, in Rennes the students had no choice and all had to participate. Several questions led to (at least partial) answers or clues for future work. These questions are:

- Can PBL be used to teach medical informatics, and what is the pre-requisite?
- What are the conditions for further integration of such courses in the learning process?

4.1. PBL

As also reported by other authors (e.g., [11,12]), we have shown that the PBL approach can be adopted for medical informatics. PBL must follow a particular sequence. In PBL-in-MI sessions, the Maastricht ''seven jump'' sequence has been applied as much as possible. Among the seven steps which are (1) clarify working definitions, (2) define the problem, (3) analyze the problem, (4) classify possible explanations, (5) generate learning objectives, (6) research the learning objectives, and (7) report back, the only step that was not as developed as in standard PBL was the fourth one. Rationale for not developing that step was that the PBL-in-MI cases did not require mechanisms equivalent to formulation of hypotheses, and knowledge of physiopathological processes.

While the overall opinion of the students was good, students in Rouen were more enthusiastic about PBL-in-MI than students in Rennes. The two groups differ according to two factors, leading to the following possible explanations. When students enroll on a voluntary basis rather than on a com-

pulsory basis, only 60% of the students participate in PBL-in-MI but almost all are enthusiastic. On the other hand, when students enroll on a mandatory basis, 100% participate but only 54% are enthusiastic. Competency in PBL may also influence student's opinion. Students who are used to participating in PBL sessions are more likely to find PBL satisfactory than first-ever participants. However, since more than one factor may be considered to distinguish between the two groups, the contribution of each factor cannot be analyzed separately.

Three different tutors participated in PBL-in-MI program (one tutor in Rouen, two tutors in Rennes). All were faculty members qualified in medical informatics. Two of them (one in Rouen, one in Rennes) had previous training in PBL. The untrained tutor reported difficulties in knowing when and how to intervene, as his/her role was to manage the group and help students to find answers on their own. This difficulty, already mentioned in other studies [17] highlights that first-ever tutors in a new problem-based curriculum may experience difficulties in-group functioning even when they are involved in the building of the PBL cases and completely adhere to the PBL philosophy. However, after the analysis of Rennes students' answers, the impact of tutor naivety remains unclear. For most of the questions, no significant difference was found between the answers of the students tutored by the naive teacher and the answers of the students tutored by the trained teacher. For two questions, the results were even significantly better for the naive tutor. These results were somewhat unexpected. However, it may be noticed that the untrained teacher tutored most of the sessions, resulting in a smaller number of answers related to the trained tutor.

More generally, when they were asked to compare PBL and academic courses, trained students gave significantly higher scores for PBL than for academic courses ($p < 0.0001$). In Rennes, the fact that the students were naïve students for PBL prevents us from interpreting the results. However, even in Rennes, student's opinions were mostly in favor of PBL. The main disadvantage that was reported by a few students in Rennes was that PBL was time-consuming.

4.2. Integration in the learning process

ICT technologies should be integrated into the normal practice of learning so that they become transparent to the user. In Rennes as well as in Rouen, the PBL-in-MI sessions take place in computer laboratories. Our opinion, following Ishijima [18], is that they should ideally be more integrated to the clinical course and included in clinical PBL blocks. However, that scenario would be time-consuming for the MI teachers.

A means to extend this experiment is to offer students possibilities to use computers in clinical wards so that they can integrate ICT into their daily ward work. Steele et al. reported studies of student learning preferences [19]. They observed that resistance to use of ICT, regardless of attitudes to and aptitude with computers was associated with ease of access, among other factors. Time is so short for medical students that convenience of use, including ease of access, is a high priority. Similarly, Vogel and Wood [20] reported comments such as 'after an 8-h day at the hospital I do not feel like coming into college to use [the computer labs]'. The Pedagogical Network in Rennes has been deployed since the early 1990 and consists of a network of computers dedicated to students and freely accessible in each clinical ward or laboratory [21].

Nowadays, undergraduate teaching of medical informatics is positioned in Rennes and Rouen Universities in the second and third years of the medical curriculum. A study conducted by Kern in 1999 showed that, according to students' opinions, medical informatics should be positioned in the last 2 years for 63% of second-year students, and 36% of sixth-year students, in the middle of the curriculum for 11% of second-year students, 21% of sixth-year students, and at the beginning of the medical curriculum for 26% of second-year students, and 43% of sixth-year students [22]. In our study, although the overall opinion of the students was good, a couple of students mentioned that ICT learning was of low interest compared to clinical practice. These third-year medical students wanted to spend more time in medical wards and focus on clinical skills. Therefore, according to third-year students' opinion as it was expressed during these PBL-in-MI sessions, ICT learning should better come at the end of the medical curriculum. However, further work would be needed to study the opinions of sixth-year students and compare them to third-year students.

5. Conclusion

Most medical schools have adopted the PBL approach. They have also recognized the needs for future generation of doctors to be familiar with the application and scope of information technology. We have explored how medical informatics can be taught in a PBL environment and found that the attitudes and opinions of students were plausibly related to their motivation and to their previous PBL competency. The PBL approach can be adopted

Summary points

- Problem-based learning to teach information and communication technology is feasible.
- The overall opinion of the 177 students from Rouen and Rennes Medical Schools was good: 69.8% responded positively to the program.
- Students were significantly more enthusiastic when they had previous PBL competency.

for medical informatics. Such courses could be ideally included in PBL clinical blocks.

Acknowledgements

The authors thank Bernard Grosbois and François Guillé for their support.

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