

PROBLEM-BASED LEARNING

Format of Cases Affects Learning Outcomes in First Year Medical Students

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ABSTRACT **Context:** Longitudinal problem-based learning (PBL) tutorials are practiced at the Tokyo Women's Medical University. First year medical school students—most of whom are high school graduates with no medical background—often encounter difficulty identifying problems while solving PBL cases in basic science. The format of PBL case presentation may affect learning.

Objectives: This study compares the learning outcomes of two cohorts of first year students who learned basic human biology through PBL cases presented in clinical vs. non-clinical formats.

Methods: All first year students in 1995 and 2000 undertook PBL tutorials. The 1995 case was presented in a non-clinical format; the 2000 case was presented in a clinical format. Both cases had five identical pre-set learning objectives in basic science. By examining all written materials generated during the tutorial sessions, learning outcomes were categorized and the accomplishment of preset objectives was analysed.

Findings: In 2000, the number of learning outcomes for clinical medicine was more than double compared to 1995, whereas the numbers of total and basic science learning outcomes were not significantly different. The number of preset objectives accomplished by the students was significantly higher in 2000. Thus, PBL case format affected the learning outcomes, enabling these first year students to achieve basic science objectives, while enhancing their interest in the clinical aspects of human biology.

Conclusion: Learning outcomes in first year medical students may be enhanced when PBL cases designed to learn basic science contain relevant clinical elements.

KEYWORDS *Problem-based learning, cohort study, high school graduates, learning outcomes, early clinical exposure, case construction.*

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Introduction

The positive impact of early clinical exposure in a four-year medical school programme designed for college graduates has been reported (Hmelo, 1998; Matson *et al.*, 1999). Medical schools in Japan and some other countries have a 6-year undergraduate programme and admit high school graduates (Kozu, 1998). A small number of students with bachelor's degrees enter these medical schools. Beginning medical school students have to learn basic science before they study clinical subjects. Student motivation to learn basic science is often enhanced through understanding the link to clinical medicine (Sweeney, 1999; O'Neill *et al.*, 2002). Problem-based learning (PBL) is used as an educational modality to link basic science to clinical medicine for first year medical school students with bachelor's degrees (Kaufman & Mann, 1997; Thomas, 1997; O'Neill, 2000). However, the impact of PBL on first year undergraduates who just graduated from high school is not known, nor has the effect of incorporating clinical elements in PBL cases designed for students with little knowledge of medicine been addressed.

The PBL curriculum at Tokyo Women's Medical University (TWMU) consists of a 4-year pre-clinical curriculum followed by a 2-year hospital and clinic-based clerkship (Yoshioka, 1994). The pre-clerkship curriculum is a hybrid of lectures, PBL tutorials and laboratory works. It is divided into blocks including human biology, functional systems of the human body, and life cycle. Each block consists of 30% PBL, 50% lectures, and 20% laboratory works. PBL starts from the first semester of the first year as a part of Block 1, the human biology course. The first four PBL cases are designed to introduce PBL and familiarize students with the tutorial method. Regular PBL tutorials with various learning objectives start with the fifth case. Cases in this block are designed to cover chemical, biological, physical, physiological, biochemical and anatomical subjects by presenting laboratory findings or natural phenomena. They are considerably different from the cases used in later blocks which are given as clinical case presentations. TMWU programme evaluation data indicates that first year students find it difficult to set self-learning objectives in basic science. At TMWU, an argument has been made for including clinical elements in PBL cases designed to study basic science, due to the fact that many beginning students may not address clinical subjects properly and miss or skip over the basic science knowledge required to understand clinical medicine in the future. This curricular orientation is consistent with the traditional Japanese medical education system in which curricula were firmly separated into pre-medical and medical courses (Hafferty, 1998).

Objectives

This study was designed to examine whether the format of PBL case presentation affects the accomplishment of learning outcomes and objectives

in basic science among first year medical school students. Two cohorts of first year medical school students with similar backgrounds undertook PBL tutorials in biology of the endocrine system, using cases presented in either a non-clinical or clinical format. The performance of each cohort was compared with respect to learning outcomes for clinical and basic sciences, as well as the accomplishment of preset learning objectives in basic biology.

Methods

Study Groups

The first year medical school students of 1995 ($n=102$) and 2000 ($n=104$) were enrolled in the study (Table 1). Seventy per cent of the first year students entered medical school by passing an entrance examination; the pass/fail ratios of the students were similar in 1995 and 2000. Thirty per cent of students entered based on the recommendation of their high school and an interview. Students in the present study had no formal clinical experience except a tour of the hospital and training in basic life support given as part of the TMWU orientation programme. The first year curriculum consists of premedical sciences such as biology, physics, chemistry and some basic medical sciences such as gross anatomy and histology. The curriculum and format of learning was not altered between 1995 and 2000. Thus, the two study cohorts had similar educational backgrounds at the outset of the study.

PBL Cases

The PBL cases compared in the study were both presented during Block 1 of the first year curriculum. The selected case fulfilled the following criteria: (1) the case was presented during an early stage of the curriculum, before studies become oriented toward clinical medicine (Block 1, Case 11 in 1995; Block 1, Case 13 in 2000); (2) the students had been familiarized with PBL when the case was given; and (3) the learning objectives were identical for both years.

Table 1. Characteristics of 1995 and 200 cohorts

	1995	2000
Total number of students	102	104
Number of high school graduates	96	97
Number of college graduates	4	3
Pass/fail ratio of entrance examination	10.4	11.2
Total number of PBL tutorial groups	16	16

Participants include repeaters from the previous year; two in 1995 and four in 2000.

Each case had five identical preset learning objectives regarding the endocrine system which were not disclosed to the students. The tutors were researchers and educators in TWMU's basic science departments. No clinicians tutored PBL during Block 1. In 1995, the case was presented in a non-clinical format and in 2000, it was presented in a clinical format. The 1995 case was designed to draw out interest in the endocrine system. The 2000 case described clinical situations in which a patient received hormone therapy (Table 2). The same author constructed both cases, using language familiar to recent high school graduates.

Table 2. Comparison of learning objectives

Learning Objectives 1995 and 2000

1. Learn the concept and definition of endocrine and hormone.
2. Explain the major endocrine organs and hormones produced by the organ.
3. Describe the anatomy of the hypothalamus, pituitary gland and adrenal cortex.
4. Explain feed back regulation of hormone, hypothalamus-pituitary-adrenal cortex as a model.
5. Learn physiological function of the adrenal glucocorticoids.

	1995 Case Non-clinical format	2000 Case Clinical format
Sheet 1	Our body has a function to maintain "a delicate balance", to keep certain substances at certain levels.	<i>Haruko, a first year medical school student, talks to her classmate, Akiko.</i> Haruko: Do you think the shape of a girl's face changes by taking a drug? Akiko: I don't know. Why? Haruko: My niece has been hospitalized in the TWMU hospital for a long time. When I saw her yesterday, I was really surprised to see that her face looks like a full moon. I heard that it is a side effect of hormone therapy.
Sheet 2	"What is a delicate balance?" thought the first year medical student, Fumiko. She thought about hormones, vital substances for human.	<i>Haruko and Akiko continue to talk.</i> Akiko: Why can't she quit taking the pill? Haruko: They do not recommend quitting the drug suddenly.
Sheet 3	She heard that both excess and shortage of hormones such as adrenal glucocorticoids are sometimes life threatening.	

The original cases were written in Japanese. TWMU: Tokyo Women's Medical University.

Assessment and Accomplishment of Learning Outcomes and Objectives

Learning outcomes were assessed based on review of the materials written on an electronic black board by the students during each tutorial session. The students used the board to organize and summarize the discussions during the session. This blackboard allowed copying from the board to paper. All sheets (206 in 1995 and 196 in 2000) were reviewed and itemized by a reviewer (TY) who was not involved in the case development or tutorial sessions. Learning outcomes that had been substantially addressed were itemized and categorized into basic science, clinical medicine, psychosociology (behavioural science) and epidemiology. A learning outcome was defined as an issue discussed substantially, typically producing more than one sheet of copied material. Topics that were only touched upon (a few lines on a sheet) were regarded as not substantially addressed. Learning outcomes related to one or more of the five pre-set objectives were tabulated. The number of learning outcomes that covered the pre-set learning objectives was used to produce an index of accomplishment of objectives.

The quality of learning outcomes for basic science was evaluated by counting the number of PBL groups in each year that studied (1) detailed structures of hormone molecules; (2) detailed feedback mechanisms of at least one hormone; and (3) molecular mechanisms of hormonal action. These learning objectives topics had not been taught in high school indicating the students learned them through PBL.

Statistical Analysis

Analysis was performed on data obtained from all 32 PBL groups, 16 in each study year. A non-parametric test (Mann–Whitney's *U*-test) was used for statistical analysis of the number of learning outcomes achieved, and Fisher's test was used for comparing the number of groups that studied defined topics in basic sciences. The level of significance was defined as $p < 0.05$.

Results

Learning outcomes are summarized in Table 3. The average number of total learning outcomes covered by each small group was slightly higher in 2000 but the difference was not statistically significant. There was no statistically significant difference in the number of basic science learning outcomes between 1995 and 2000. However, the 2000 class addressed significantly more issues related to clinical medicine. In 1995, 12 of 16 groups itemized less than one clinical issue; in 2000, ten groups itemized more than two clinical issues. No psychosociological (behavioural science) or epidemiological issues were itemized in either cohort. The number of human biology (basic science) objectives accomplished was significantly higher in 2000. In 1995, three groups covered all five human biology objectives; in 2000, eight groups covered the same five

Table 3. Learning outcomes in 1995 and 2000

	Total issues	Basic science	Clinical medicine	Psycho-sociology (behavioural sci.)	Epidemiology	Objectives accomplished
1995 (non-clinical format)						
Average per group	7.9	6.9	0.9	0.0	0.0	3.6
SD	1.6	1.4	0.9	0.0	0.0	1.0
2000 (clinical format)						
Average per group	8.5	6.4	2.1	0.0	0.0	4.3
SD	1.5	1.2	1.1	0.0	0.0	0.9
Significance 1995→2000	$p=0.350$	$p=0.350$	$p=0.026$	N/A	N/A	$p=0.028$

Mann–Whitney’s U -test was performed; p values are shown; N/A: not applicable.

objectives. In 1995, a total of 126 issues were addressed; in 2000, this number rose to 136.

A qualitative analysis of learning outcomes showed some characteristics of the students in 2000. The number of groups that studied detailed structure of hormone molecule (12 and 14 out of 16 groups in 1995 and 2000, respectively) and detailed feedback mechanisms (14 and 15 groups) were not different between the 1995 and 2000 classes. However, the number of groups that studied molecular mechanisms of hormone actions more than doubled in 2000 (12 groups) compared to 1995 (five groups) ($p < 0.04$). Most groups in 2000 studied molecular mechanisms of action of steroid hormones which are taught in lectures in the second year.

Discussion

Self-directed learning is facilitated when learners are motivated, familiar with the material, and have a sense of how the learning process takes place (Merriam & Caffarella, 1999). For first year medical students learning basic human biology, clinical medicine is a rather remote subject. Moreover, they are experiencing a transition from the teacher-directed learning common in high schools to the student-directed learning which is key to the PBL process. Learning basic science through PBL requires the learner to develop the ability to set learning objectives (Schmidt, 1993). Thus, students who are recent high school graduates may confront difficulties adjusting to a new learning process as well as linking what they are currently learning to what they will learn in the future. The present study demonstrated the effect exposure to the clinical issues within a PBL case study context.

The present study examined whether at the outset of medical education, basic science learning is enhanced by using a PBL case that contains clinical elements. When compared to the 1995 case, the clinically-oriented 2000 case significantly increased the number of clinical issues covered by the students. Interestingly, despite an emphasis on the clinical context in the 2000 case, the accomplishment of learning objectives in basic science was greater in 2000 than in 1995. Thus, the students in 2000 who were presented with a clinically-oriented PBL case demonstrated clinical interest while at the same time mastering more basic science learning objectives than the 1995 students who were presented the same case in a non-clinically oriented format. Although the design of cases may affect the learning activities (Mpofu *et al.*, 1997); judged from the total numbers of learning issues, both cohorts seemed to demonstrate comparable learning activities in 1995 and 2000. It is notable that many groups in 2000 studied fundamental molecular mechanisms of hormonal actions that are part of the learning objectives, while the same number of groups in 1995 and 2000 studied general objectives such as classification of hormones

and feedback mechanisms. The clinically-oriented case may have evoked students' interest and motivation to learn basic mechanisms presented in both case constructions.

The students in 1995 and 2000 did not address psychosociological (behavioural science) or epidemiological issues. These areas are the learning objectives for later years, and learning related to these topics may be difficult for first year students.

However, the present study clearly showed that first year students with no background in clinical medicine demonstrated substantial interest in solving clinical problems using PBL, and yet focused their learning on objectives appropriate to their stage in the medical school curriculum. It is still premature to conclude that all PBL cases in the early or basic sciences should include clinical aspects. However, early clinical exposure in some PBL cases may increase the students' motivation and understanding of the process of learning and the interconnections between basic science and clinical medicine.

The medical education system as well as the style of PBL differs among countries and medical schools (Maudsley, 1999; Pfeiffer *et al.*, 2001). Our findings may not be applicable to all PBL-based curricula, which are conducted in diverse cultural and educational settings. Nevertheless, our experience highlights some of the interesting issues related to the use of with students who are not familiar with medicine. This study also illustrates the importance of case format in facilitating self-directed learning.

Conclusion

Including clinical elements in PBL cases for learning basic or pre-clinical sciences enhances the learning outcomes of first year medical school students who have just started self-directed learning. Early clinical exposure in the medical curriculum by presenting a carefully structured clinical context in PBL can foster a link between basic and clinical sciences.

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