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RESEARCH ARTICLE

Quantitative evaluation of problem-based learning outcomes on student pharmacists' patient care process in Japan

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Abstract

Background: This study aimed to evaluate the learning effects of problem-based learning (PBL) by quantitatively comparing the medication management abilities of PBL practitioners (the PBL group) and non-practitioners (the non-PBL group) among pharmacy students in Japan. **Methods:** An outpatient-based pharmacy practice simulation was conducted using electronic medical records (EMRs) to assess both groups based on the Pharmacists' Patient Care Process (PPCP) concept. **Results:** The median values for the non-PBL group and the PBL group were, respectively, 34 and 51 points for "*Collect*", 22 and 23 points for "*Assess*", 11 and 20 points for "*Plan*", 20 and 36 points for "*Implement*", and 4 and 11 points for "*Follow-up*". **Conclusion:** The learning effects of PBL were significant for each step of the PPCP except for the "*Assess*" domain. It is suggested that a roadmap be developed to enhance medication management abilities further while also utilising EMRs and incorporating the concept of PPCP into evaluations.

Introduction

In 2014, the Joint Commission of Pharmacy Practitioners created a patient-centred care model based on a multidisciplinary collaboration known as the Pharmacists' Patient Care Process (PPCP) (Joint Commission of Pharmacy Practitioners, 2014). The primary purpose of PPCP is to enable pharmacists to optimise pharmaceutical care and be recognised as medication experts by patients and healthcare professionals (Mohiuddin, 2019). An optimal plan for teaching PPCP has been recently developed for the Doctor of Pharmacy (Pharm.D.) programme in the U.S., implementing PPCP into the curriculum and evaluating its learning outcomes (Cooley & Lee, 2018).

In Japan, pharmacists in community pharmacies play an increasingly focal role in ensuring patient safety, enhancing the efficiency of healthcare delivery, and achieving treatment goals. These responsibilities are fulfilled by assessing patients' treatment history, medical conditions, and preferences, considering the most appropriate medication, and providing accurate patient counselling. To meet these demands, documenting a medication record for each patient becomes mandatory to allow for medication management therapy in pharmacies. Electronic medication records (EMRs) should include prescribed and over-the-counter medications, patient data obtained at the pharmacy, pharmacotherapy assessments, pharmacist counselling, and details to be noted at the patient's next visit. Such records are crucial for proper patient medication management and contribute to health-promoting practices (Aldughayfiq & Sampalli, 2021). In the absence of regulatory requirements dictating the use of this format, most pharmacies utilise SOAP notes (Subjective/Objective data, Assessment, and Plan), and the number of pharmacies adopting EMRs is rapidly increasing (Ives *et al.,* 2020; Aldughayfiq & Sampalli, 2021).

In Japan, a 6-year educational programme for pharmacy schools was introduced in 2006, followed by a clinical clerkship in 2010. This clerkship includes 11 weeks of on-site training at a community pharmacy and 11 weeks at a hospital (Ozawa, 2018). Starting their fifth year, pharmacy students gain hands-on training in dispensing medications, providing medication guidance, working collaboratively with other healthcare professionals, and contributing to community health. Therefore, pharmacy schools must offer an effective preparatory education to ensure students are adequately prepared for their clinical clerkship. This programme should emphasise patient medication management, including counselling and maintaining medication records.

A roadmap is suggested to be developed to enhance pharmacists' medication management abilities throughout their education, from didactic learning to clinical clerkships. Introducing quantitative criteria for manuscripts and grades and objective tests could be valuable for evaluating progress over time (Goneau *et al.,* 2018). Additionally, creating scenarios relevant to pharmacists' work and assessing pharmacists' abilities based on the PPCP criteria would benefit both students' practical education and pharmacists' continuing education. Furthermore, using EMRs is an effective tool, providing an ideal learning environment for conducting PBL exercises, assessing achievements, and enhancing understanding of PPCP steps (Skelley *et al.,* 2018; Cook *et al.,* 2021). In Japan, achieving these objectives would require promoting the investigation of effective EMR use and developing EMRs for learning purposes.

Quantitative methods have been established to evaluate medication management abilities at pharmacies utilising EMRs by comparing the skills of fourth-year pharmacy students with those of practising pharmacists (Hirose *et al.,* 2020). The results showed significantly lower student scores regarding medication counselling and EMR documentation. Thus, educational programmes should adopt problem-based learning (PBL) in preparatory curricula for clinical clerkships to enhance students' clinical skills in patient medication management (Chan *et al.,* 2022). In 2019, Fukuyama University in Japan introduced PBL exercises for fourth-year pharmacy students. These exercises involve case studies based on hypothetical pharmacy scenarios, where students participate in small group discussions to determine how to manage medication and monitor treatment progress under the supervision of assigned faculty members. Although many medication management practices in Japanese pharmacies follow the PPCP, there are currently no reports assessing the medication management abilities of Japanese pharmacists or pharmacy students using PPCP criteria. This study quantitatively evaluated the learning effects of PBL by comparing the medication management abilities of fourth-year students in the PBL group with those in the non-PBL group. The EMR was used as the assessment medium for abilities, with the evaluation based on the PPCP concept.

Methods

Content of PBL exercises

Since 2019, fourth-year pharmacy students at Fukuyama University have participated in a learning programme simulating experiences in pharmacies while applying PBL methods. The programme aimed to foster the concept of medication management practised by community pharmacists through small group discussions (SGDs). All students were exposed to two different patient scenarios over four days: basic-level hypertension and applied-level rheumatoid arthritis (Table I). In both scenarios, a pharmacist processed prescriptions from a fictitious patient on four consecutive occasions. Students participated in SGDs for the first three prescriptions and worked individually on their assignments on the fourth day. Each SGD comprised approximately seven to eight students, and five groups worked simultaneously under the guidance of two faculty members.

Table I: Scenarios of PBL exercises

Case (level)	Disease	Prescription drug	Scene setting (exercise method, time required)			
			1st visit SGD[1], 270 min	2nd visit SGD[1], 270 min	3rd visit SGD[1], 270 min	4th visit IP[2], 270 min
1 (basic)	Hypertension	Irbesartan	X	X	X[3]	X
		Amlodipine	X	X	X[3]	X
2 (applied)	Rheumatoid arthritis	Methotrexate	X	X[3]	X	X
		Celecoxib	X	X[3]	X	X
		Folic Acid		X	X	X
		Prednisolone			X	
		Adalimumab				X

[1]SGD: small group discussion; [2]IP: individual practice; [3]Dosage has been escalated since that visit; PBL: problem-based learning

During both SGDs and individual work, students identified issues with the fictional patient, audited the prescription by applying practice guidelines and drug information resources, predicted the medication's course, and planned the details of medication counselling (Table II). They also documented daily medication using the SOAP format. The self-study tasks used to address the fictional patient's problems were discussed and evaluated by each group during the SGDs.

Table II: Assignment of problem-based learning (PBL) exercises

Issues addressed in the small group discussion and individual practice	Self-study assignments
1. Create and update the list of problems in the patient's medication.	1. Research and summarise the self-study tasks assigned in the group.
2. Audit prescriptions and inquire about questionable prescriptions as necessary.	2. Share self-study results with group members.
3. Predict future treatment course and overall health of the patient.	
4. Consider the content of the interview with the patient and the medication counselling that should be given.	
5. Record the results of medication management of the patient in the SOAP format.	

An anonymous questionnaire was administered on the final day, where students self-assessed their achievement on a four-level scale (4: excellent, 3: superior, 2: good, and 1: fair) immediately after the PBL exercise. Only students in the PBL group completed the self-assessment.

Evaluation of medication management abilities

Before the clinical clerkship training, a quantitative examination was conducted to evaluate the medication management abilities. For this assessment, data from a fictitious asthma patient scenario were input into an authentic EMR (ENIFvoiceSP+A@; Toho Holdings Co. Ltd., Tokyo, Japan). This data included the patient's background, past and current prescriptions, and medication records maintained by previous pharmacists. Faculty members explained the EMR specifications and usage, and students practised data entry on a trial basis before the examination. The examination process was structured to simulate community pharmacists' work and document suggestions from individual processes. Students' submissions were evaluated for each of the five steps of the PPCP: (1) Collect (collect patient data and identify any missing information); (2) Assess (assess and analyse past and current prescriptions to predict the patient's problems); (3) Plan (develop a treatment plan and create dialogues to explain medication use to the patient); (4) Implement (document medication counselling that occurred during a pre-arranged conversation between a simulated patient and another pharmacist); and (5) Follow-up (examine the key points during patient monitoring).

A time frame was set for the completion of all assignments (Table III).

Table III: Procedure of examination for assessing medication management abilities

Seq.	Assignments of examination	Time limit (min)	Source of information			No. of items for evaluation		
			EMR[1]	Prescription	Conversation	10 points	4 points	2 points
1	Estimate the patient background and indicate the information to be collected (Collect)	15	X			23	17	7
2	Predict the problems by analysing collected information (Assess)	20	X	X		17	8	0
	Create the dialogues with the patient for medication (Plan)					14	21	37
3	Record the overview of medication counselling (Implement)	20	X	X	X	8	2	5
	Examine the key points of patient monitoring (Follow-up)					6	4	1

[1]EMR : Electronic Medical Record

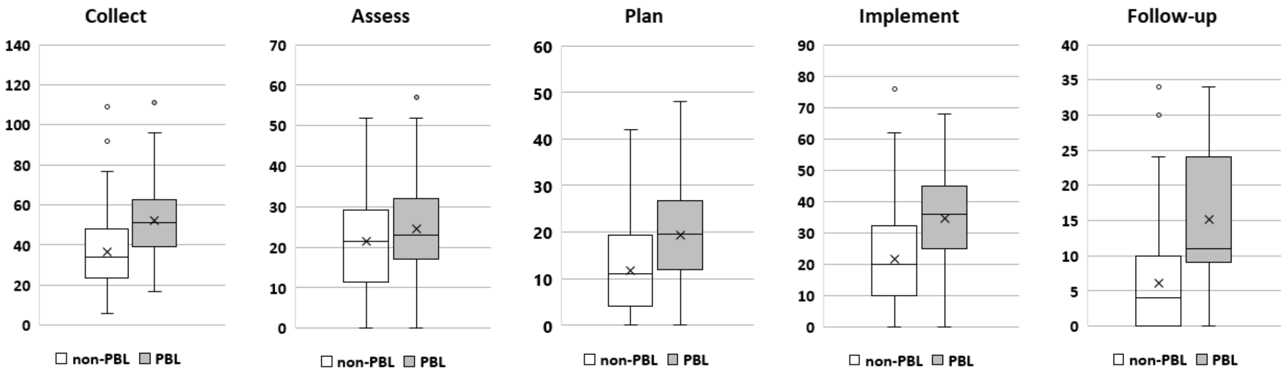
Each student's medication management ability was quantitatively measured using EMR records, following assessment criteria established in a prior study (Hirose *et al*., 2020). As pharmacists must extract crucial information from EMRs and prescriptions to provide optimal medication guidance and follow-up plans for patients, the students' recorded sentences were weighted and rated according to their importance: 10 points for essential content, 4 points for desirable content, and 2 points for content considered somewhat relevant. If a sentence's content was deemed insufficient, a factor of 0.5 was applied to the calculation. These evaluation criteria and their associated scores were determined through discussions with two university faculty members, two practising pharmacists, and one pharmacy educator.

Students who took the examination in 2017 were included in the non-PBL group, while those who took it in 2019 formed the PBL group. All fourth-year students in both groups were eligible to take the examination. Since PBL became a core subject in 2019, it was not feasible to set a non-PBL group as a concurrent control group; therefore, student evaluations were compared with those from before the introduction of PBL.

The total scores for each PPCP step were calculated, and the median scores of the PBL group (evaluated in 2019) were compared with those of the non-PBL group (evaluated in 2017). Significance levels were calculated using the Mann-Whitney U-test, with a 5% level considered significant. All statistical analyses were performed using the software EZR ver. 1.54 (Kanda, 2013).

Results

Similar studies assessing medication management abilities based on the PPCP were conducted with 142 fourth-year students in 2017 (non-PBL group) and 140 fourth-year students in 2019 (PBL group). Initially, the non-PBL group included 144 students, but due to illness, two students were absent on the examination day, resulting in 142 participants (53 males and 89 females). Of these, 131 were in their fourth year after matriculation, 10 were in their fifth year because they had repeated a year, and one was in her sixth year. In the PBL group, all 140 students (61 males and 79 females) participated in the examination. Of these, 135 were in their fourth year after matriculation, and 5 were in their fifth year after repeating a year. Students in the same group had completed the same educational programme before the examination. The study's primary endpoint was the total score of each PPCP step. The results are shown in Figure 1. The median values for non-PBL and PBL groups were as follows: 34 and 51 points ($p < 0.001$) for "*Collect*", 22 and 23 points ($p = 0.054$) for "*Assess*", 11 and 20 points ($p < 0.001$) for "*Plan*", 20 and 36 points ($p < 0.001$) for "*Implement*" and 4 and 11 points ($p < 0.001$) for "*Follow-up*", respectively.



p-value was calculated using the Mann-Whitney *U* test.

Figure 1: Comparison of total scores of non-PBL group and PBL group for each step of PPCP

The number of items above 10 points, i.e. the secondary objective, was also higher for the PBL group across all PPCP steps (Table IV). The differences between the non-PBL and PBL groups were 6.6% for "*Collect*", 2.7% for "*Assess*", 2.9% for "*Plan*", 20.5% for "*Implement*", and 13.7% for "*Follow-up*", respectively.

Table IV: Ratio of the mentions of 10-point items

PPCP Steps	No. of 10-point items	Total mentions (mention rate; %) non-PBL Group (n = 142)		Total mentions (mention rate; %) PBL Group (n = 140)		Difference
Collect	23	453	(13.9%)	659	(20.5%)	6.6%
Assess	17	333	(13.8%)	393	(16.5%)	2.7%
Plan	14	152	(7.6%)	207	(10.6%)	2.9%
Implement	8	330	(29.0%)	555	(49.6%)	20.5%
Follow-up	6	67	(7.9%)	181	(21.5%)	13.7%

The self-assessment results revealed that more than half of the students rated themselves at the highest level (Level 4) in all four categories (Table V); the highest mean value was 3.42 for Q. 2 (understanding of drug information), and the lowest was 3.35 for Q. 3 (problem-solving and individual optimisation).

Table V: Self-assessment of achievement after PBL exercises

Self-assessment category*		4	3	2	1	Average
		No. of respondents				
Q.1	Comprehension of patient information	50	25	9	3	3.40
Q.2	Understanding of drug information	55	27	11	2	3.42
Q.3	Problem-solving and individual optimisation for medication	50	30	11	3	3.35
Q.4	Monitoring of patient efficacy and safety	49	37	7	2	3.40

*4: Excellent, 3: Superior, 2: Good, 1: Fair

Discussion

The PBL exercise was designed to improve students' ability to accurately assess patient information and develop and monitor treatment plans through continuous interaction with a single patient (Nicholl & Lou, 2012; Phelan *et al.,* 2022). This study aimed to assess whether the ability of pharmacy students to manage medication varied based on their experience with PBL exercises, using PPCP steps as an indicator.

When evaluating students' total scores, results from four of the five PPCP steps indicated the effectiveness of PBL exercises. The significantly higher score related to "*Collect*" in the PBL group is likely due to students' experience exploring patient situations through assessing data from fictitious cases. The higher overall score relating to "*Plan*" is believed to arise from their improved skills in applying drug information for medication counselling. While there was no marked difference in the rate of 10-point items between groups, the higher frequency of 4-point and 2-point items in the PBL group contributed to their superior overall scores. For "*Implement*", the PBL group scored higher in both overall points and 10-point item frequency. The EMR input analysis revealed the substantial effect of repeated SOAP training formats in PBL exercises. The PBL group also scored considerably higher in the "*Follow-up*" step, indicating an enhanced ability to consider patient monitoring needs, likely due to repeated treatment surveys. Simultaneously, the study highlighted the difficulty of acquiring practical knowledge and skills only through conventional didactic lectures on SOAP concepts (Kerr *et al.,* 2020). These findings align with previous reports of higher learning outcomes in PBL implementation groups (Galvao *et al.,* 2014).

In contrast, no significant difference was observed between the two groups for the "*Assess*" step, suggesting a limited learning effect of the exercise in this area. Notably, the appropriate assessment of patient information is crucial for optimal medication management, making this capability a key objective of PBL exercises. Despite the time devoted to the "*Assessments*" step, the scores were not as high as expected. To address this issue, the PPCP exercise at Fairleigh Dickinson University recommended increasing student-faculty contact and providing timely, formative feedback while students work on assignments (Rivkin, 2016). The evaluation method used in this study involves detailed criteria and calculations, leading to less variation between evaluators. However, compared to the Rubric evaluation method, it is more timeconsuming and challenging to incorporate into the exercise plan or provide mid-term feedback (Vyas *et al.,* 2019). Furthermore, this ability could be acquired through experience with a certain number of cases. Students' understanding of each PPCP step was found to improve through repeated practice (Gonyeau *et al.,* 2018; Skelley *et al.,* 2018). It is worth noting that the main barriers to introducing PBL in Japan, as elsewhere, include training tutors and securing space and teaching time for small classes (Galvao *et al.,* 2014). The tutorial approach should be refined, alongside repeated PBL exercises (Phillips *et al.,* 2019), to accommodate limited faculty resources in answering students' questions, even online, by sharing these inquiries with their colleagues (Nicholl & Lou, 2012).

The self-assessment questionnaire revealed high scores for all four items evaluating students' perceptions of their achievement. While these results lack objectivity due to their self-reported nature, they indicate that students are aware of the increase in their knowledge and skills resulting from PBL exercises, suggesting a high level of engagement and motivation for participating in these exercises. A previous study found that students with PBL experience reported satisfaction from contributing to SGDs; hence, it is considered beneficial to introduce both individual and small group assessments in PBL (Jones, 2005).

Limitations

This study has several limitations. First, for assessing the competence of each step of the PPCP, some elements were not practical; the examination lacked opportunities for students to collaborate with other healthcare professionals in medication use. Drug therapy practice should involve interdisciplinary collaboration in real-world practice. Second, the "*Implement*" assignment did not include interpersonal tasks, such as patient instruction. Instead, it was only evaluated based on the students' EMR entries after listening to a prepared mock medication instruction. A study at the University of Georgia found that formative evaluation of students' oral explanations was only effective in improving "*Implement*" skills (Phillips *et al.,* 2019). Therefore, future studies would benefit from evaluating students' medication instructions to simulated patients, addressing this limitation in the next phase. Third, while the procedures used to assess medication management abilities aligned with actual pharmacy practice, the time limit allotted to students for each task during the examination was considerably longer than the time available in a medical setting, potentially limiting the generalisability of the results to real-world scenarios.

Conclusion

The learning effects of PBL were evaluated for each of the PPCP steps through an examination simulating outpatient-based pharmacy practice. The results showed that abilities in "*Collect*", "*Plan*", "*Implement*", and "*Follow-up*" were significantly enhanced in the student group exposed to PBL. However, for the ability to "*Assess*", the study identified the need to establish a continuous educational method to develop pharmacy management abilities through exposure to numerous cases, including factual experience in clinical clerkships, and enhance simulated learning methods using PBL.

In conclusion, this study suggests implementing ongoing PBL exercises that reflect actual pharmacist operations while utilising EMR and incorporating the PPCP concept into evaluations. Such a combination is expected to build a more effective method for practical education while also serving as a model for advancing pharmacy education globally.

Ethics approval and informed consent

This study was approved by the Fukuyama University Research Ethics Review Committee (approval number: H30-Human-18).

Before the study began, all participants were informed that these results might be published anonymously in a paper. Additionally, students were given the option to decline the publication of their results after statistical processing.

Conflict of interest

The authors declare no conflict of interest.

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