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Impact of research-based learning on student knowledge and assessment in pharmacoepidemiology: A one-group pretest-posttest experimental study

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ABSTRACT

Introduction: Research-based learning (RBL) is an active way of engaging students and engendering research skills. **Objectives:** The objectives of the study were to examine the impact of RBL on student knowledge and assessment. **Materials and Methods:** RBL was run as a one-group pre-test/post-test experimental study where the 4th-year pharmacy undergraduates (n = 84) taking the basic pharmacoepidemiology course were the participants. RBL was incorporated into the course as a strategy to build small-scale real-life research projects into undergraduate assignments. The RBL intervention was assessed as student knowledge of the selected topics and their assessments of the teaching. **Results:** Eighty-three valid responses were analyzed (response rate, 98.8%). The mean accumulated grade point average of participants was 3.28 (SD = 0.39). Most were female (77.1%). According to relevant student knowledge of the selected topics, the post-test score increased after the RBL intervention (mean = 17.6, SD = 2.1) compared to the pre-test score (mean = 9.7, SD = 2.9); t (82) = −21.1. After implementing RBL, 74 students completed a 20-item end-of-semester questionnaire where the overall score was 4.0 (SD = 0.5), deemed to be a good level of teaching. **Conclusions:** RBL promises to impact on student knowledge and teaching assessment, especially good student satisfaction. Better designed protocols investigating the role of RBL in skill acquisition are needed to overcome ethical and design constraints.

Keywords: Pharmacoepidemiology, Pharmacy, Pharm D, Research-based learning, Thailand

INTRODUCTION

Research-based learning (RBL) is based on the preposition that learning builds on existing understanding, by developing prior knowledge, through real experiences.[1] It relates to problem-based learning, authentic learning, problem-solving, and cooperative learning.[2] However, RBL differs using the research process as the focus for engaging learners. Learning activities can be designed around contemporary research issues, thereby introducing research methods and skills explicitly within a program. These can be extended to

undergraduate assignments that engage students in research projects. Thus, here, we rigorously apply the word "research" (or scholarly research) to mean generation of live small-scale research into an undergraduate assignment.

RBL makes students' part of the research culture and engenders interest in research careers.[3] RBL develops research competency and critical thinking while elevating student satisfaction.[1,4] Deep learning and understanding are fostered in undergraduate students, particularly by linking teaching to research.[5,6] Curricular in health sciences is credit-based courses, so students lose sight of the integrated functionality of their discipline.

RBL has been applied to education, sciences, and engineering[1,4,7,8] where positivism is supported. The increasing diversity of pharmacy in health care advances in therapeutics and the increasing understanding of diseases places further demands on pharmacy graduates who need to adapt to changing social settings and unpredictable demands.[9] Pharmocoepidemiology was traditionally lecture based. So far, no study has specifically investigated the impact of RBL on pharmacy students. Here, we aimed to test the impact of RBL on student knowledge and assessment in pharmacoepidemiology to prepare pharmacy students for their future roles in society and ultimately contribute to health care and patient safety.

MATERIALS AND METHODS

Setting

The Doctor of Pharmacy degree in Pharmaceutical Care (Pharm D) at Naresuan University is based on a 6-year pharmacy curriculum and was the first pharmacy school in Southeast Asia to offer direct undergraduate entry into a doctorate pharmacy program. The course is modeled on various teaching and learning activities and fosters critical thinking and a working knowledge. The curriculum strongly emphases basic and pharmaceutical sciences, while developing professional experience that facilitates acquisition of professional skills necessary for pharmacy practice. This study took place within the 4th year Pharmacoepidemiology module (2 credits). It aims to help students understand the concepts of basic epidemiologic methods, to read, analysis, and critique research findings in pharmacoepidemiology as applied to pharmacy practice. There are no enrollment prerequisites among pharmacy students. Content includes pharmacoepidemiology principles, research design, relevant statistics, measurement and source of data, meta-analysis, and applications to pharmacy practice. The course has 2 h/week classroom or faculty instruction (contact hours) and 4 h out-of-class work/week for the 15-week semester. The course had two course directors, another two academic lecturers, and one guest lecturer (Thai Food and Drug Administration, Ministry of Public Health). Recommended textbooks were for pharmacoepidemiology,[10] modern epidemiology,[11] and principles that promote medication adherence.[12] Course contents are shown in Table 1.

Study Design

This was a one-group pretest-posttest design.

Study Participants

The 4th year pharmacy undergraduate students (n = 84) registered for the basic pharmacoepidemiology course, were the research participants. Naresuan University Institutional Review Board determined this project as educational research conducted in-house and, therefore, exempted from formal application for approval.

Table 1: Content and schedule for the pharmacoepidemiology course

Week	Topic	Teaching method
1	Course introduction, pharmacoepidemiology, and public health	Didactic method (lecture and discussion/case study)
2	Outbreaks of disease	Didactic method (lecture and discussion/exercise/case study/real practice)
3	Risk assessment	Didactic method (lecture and discussion/exercise/case study/real practice)
4	Observational study designs in pharmacoepidemiology	Research-based learning
5	Experimental study designs in pharmacoepidemiology	Research-based learning
6	Screening and diagnostic testing	Issue-based learning
7	Tutorial and practice for topic 1–6	Exercise/discussion/case study/demonstration
8	Identification and data analysis in pharmacoepidemiology	Didactic method (lecture/discussion/exercise/case study)
9	Quality of data and bias in pharmacoepidemiology	Didactic method (lecture/discussion/exercise/case study)
10	Pharmacovigilance	Issue-based learning
11	Signal detection system and pharmacovigilance in Thailand	Didactic method (lecture/discussion/exercise/case study)
12	Pharmacoepidemiology: An application in pharmacy practice	Didactic method (lecture/discussion/exercise/case study)
13	Meta-analysis	Didactic method (lecture/discussion/exercise/case study)
14	Meta-analysis–Examples	Didactic method (lecture/discussion/exercise/case study)
15	Tutorial and practice for topic 8–14	Exercise/discussion/case study/demonstration

Study Tools and Data Collection

The RBL intervention was specifically incorporated into this course as a strategy to build small-scale research projects into undergraduate assignments. RBL-related activities were explained to all these students verbally and written into the course syllabus and lesson plan as part of the selected topics, "observational study design" and "experimental study design." Students earned points based on completeness and quality for their assignment (i.e., conducting a mini observational and experimental project, data collection, writing a report, and an oral presentation). The topic assigned was "medication non-adherence in my family." The RBL intervention comprised specifically of activities listed in Table 2. The impact of the RBL intervention was assessed in terms of the students' knowledge of the selected topics and teaching assessment. A quasi-experimental study using a "one-group pre-test/post-test" design was conducted. Students were given a single pre-test, then the intervention (RBL) was implemented, and finally, they took a post-test. The assessment instrument of pre- and post-tests was designs based on the learning objectives that included (i) to understand characteristics of observational and experimental study designs; (ii) to be able to differentiate observational and experimental studies from other epidemiological studies; and (iii) to understand and be able to apply relevant measurement and data analyses for observational and experimental studies. Both pre- and post-tests were appraised for face validity, whether the test items were relevant to the main learning construct. The evaluation was conducted by two course directors and one external reviewer all of whom had >3 years of experience in the field of pharmacoepidemiology. The total maximum score was 20 for each pre- and post-test. Students were allowed 30 min to complete the test which was done in class.

Students also completed the faculty questionnaire that assessed teaching for the selected topics. The first part comprised 20 items, of which 16 specifically related to teacher activity and delivery and 4 items about student activity and outcomes. Each item was scored on a 5-point Likert-type scale: Excellent (5), good (4), fair (3), poor (2), and very poor (1). In the second part, student opinions were sought about teaching and/or improvements by posing open-ended questions. Students answered the questionnaire anonymously at the end of semester and directly taken to the department office. The data were independently analyzed by the Faculty Unit of Academic Affairs.

Data Analysis

The Statistical Package for the Social Sciences software version 23 was used to analyze the data and 0.05 significance threshold. Descriptive statistics were used to summarize demographic variables and paired *t*-tests used to compare pre- and post-test scores.

RESULTS

Response Rates and Sample

Eighty-three valid responses were included in the data analysis (response rate of 98.8%). The majority of participants were female (77.1%). The mean accumulated grade point average of participants was 3.28 ± 0.39 who originated from central (54.2%), northern (36.1%), and Northeast Thailand (9.6%). The faculty teaching assessment was completed by 74 students (89.2% response rate).

Table 2: RBL intervention activities in the topics "Observational study design" or "Experimental study design"

Activity	Detail	Duration and teaching method
Development and planning	Class preparation that involved reading online teaching materials through the Moodle system before the class	1 week self-study theory
"Observational study design"	1. Teaching activity consisted of 35 min presentation by an instructor giving information regarding RBL, objective of learning topic, assessment, and pre-test 2. Students carried out a mini observational study on a real-life topic "medication non-adherence in my family" by telephone interview of their parents/relatives who were being prescribed medications and who had already agreed to participate in this mini study. Morisky Medication Adherence Scale, a standard tool for measuring adherence, was used[30] and the observation was recorded through an online data collection form	2 h self-study individual practical
Analysis planning	Classroom-based facilitator-led instruction of data analysis techniques	2 h facilitated classroom theory and practice
Design an intervention	Students worked in small groups to design a mini experimental study "intervention for dealing with non-adherence to medication." Each group was a mix of students having parents/relatives with good adherence and those with poorly adherent parents/relatives	2 h self-study group practical
Student-led intervention	Students implement their designed intervention, for example, by consultation or text message reminders to parents/relative	1 week self-study individual practical
Follow-up consultation	Parents/relatives were reinterviewed through telephone to assess adherence and the result entered into an online form	1 week self-study individual practical
"Experimental study design" class	Each group gave a presentation about their study design and findings, while other groups asked questions and/or gave feedback; students with help from the facilitator extracted core knowledge of observational and experimental study design; the facilitator filled in gaps in student knowledge and suggested relevant references for further reading	2 h classroom-based group work theory

RBL: Research-based learning

Impact of Intervention

Participant knowledge of study design

Student knowledge of observational and experimental study design is summarized in Table 3. The post-test scores almost doubled compared to pre-test scores for both topics: Their knowledge of observational study design than experimental study design.

Teaching assessment after implementing RBL

At the end of the semester, 74 students completed the faculty questionnaire. Across 20 items, overall score was 4.01 (SD = 0.52, maximum score 5), deemed to be good level of teaching. Students expressed satisfaction with teaching (mean = 4.03, SD = 0.66) and the highest score was for preparedness of teacher for teaching (mean = 4.32, SD = 0.72). The lowest scores were identified in the following items: "Teaching methods that maintain student interest throughout the class duration" (Mean = 3.77, SD = 0.82) and "able to apply learning to real-life situations" (Mean = 3.77, SD = 0.73) [Table 4]. All items were rated as good. Student opinion about teaching and/or improvement from open-ended question included (quote) "the content for these topics was difficult but the teaching was able to make us understand."

Table 3: Comparisons of pre-test and post-test score for the selected topics (n=83)

Study topics	Score		
	Pre-test mean (SD)	Post-test mean (SD)	*P* value
Observational study design	4.2 (2.3)[a]	9.0 (1.1)	<0.001[b]
Experimental study design	5.6 (1.8)	8.6 (1.4)	<0.001[b]
Total	9.7 (2.9)	17.6 (2.1)	<0.001[b]

[a]n=81 (two students were absent for then "observational study design" part of the pre-test). [b]Paired *t*-tests, pre- and post-test

DISCUSSION

This study examined the benefits of RBL to achievements by pharmacy undergraduates in the pharmacoepidemiology course. Its strength was application a high-level RBL strategy (a live small-scale research project) enabling students to learn study design by experiencing real data collection and analysis from relatives having chronic diseases commonly encountered in pharmacy practice. It introduced a practical element into a traditional classroom taught subject. However, in common with other teaching interventions, ethical and practical constraints prevented employment of a two-arm randomized controlled trial design.

Table 4: Teaching assessment for the selected topics using RBL (n=74)

Topic	Mean (SD)	Interpreted score
Teacher activities and delivery		
Clear teaching schedule	4.16 (0.72)	Good
Clear learning objectives	4.14 (0.65)	Good
Preparedness of teacher for teaching	4.32 (0.72)	Good
Clear criteria for assessing learning outcomes	3.99 (0.73)	Good
Clear and understandable course content	3.97 (0.74)	Good
Appropriate examples	3.92 (0.74)	Good
Appropriate teaching materials	4.04 (0.77)	Good
Clear answers to student queries	3.97 (0.66)	Good
Periodic assessment of student learning and feedback in the classroom	4.01 (0.80)	Good
Teaching methods that maintain student interest during the class	3.77 (0.82)	Good
Punctuality	4.30 (0.68)	Good
Giving opportunity for students to enquire and express opinions	4.12 (0.74)	Good
Coverage of declared content	4.23 (0.69)	Good
Suggestions about further information sources	3.85 (0.82)	Good
Checking the assignments and providing helpful feedback	3.93 (0.71)	Good
Giving opportunity for consultation in and outside the classroom	4.01 (0.77)	Good
Student activities/outcomes		
Knowledge and understanding arising from the teaching	3.80 (0.76)	Good
Ability to apply learning to real-life situations	3.77 (0.73)	Good
Overall student satisfaction to teaching	4.03 (0.66)	Good
Interest in further learning facilitated from the teaching	3.80 (0.70)	Good
Total	4.01 (0.52)	Good

RBL: Research-based learning

The main end point, the elevated post-test score, accords with similar inquiry-based methods used in the fourth-grade school science courses.[13,14] Limited student understanding about observational and experimental study design was confirmed by student comments that these topics were difficult to understand in response to open-ended questioning. Nevertheless, the higher score after implementing RBL suggests that it could contribute to learning gains. This aligns with the previous reports for the role of RBL in student learning,[15,16] supporting suggestions that learning is improved by active engagement.[17]

The questionnaire on teacher performance rated teaching as "good" including their satisfaction with the RBL experience as also shown previously,[18] especially science disciplines.[13] RBL implementation depends on facilitator readiness, as highlighted in the student assessment of teaching that for RBL was rated as good (4.32 + 0.72).

Students also successfully assessed the adherence of their parents/relatives to medication using a protocol where the students determined the intervention. The protocol should enable pharmacists to improve medication safety and quality of life, for example, patients domiciled at home;[19] those visiting hospital with medication-related problems;[20] or diabetic patients who poorly adherence to their medication. These are globally relevant as the World Health Organization noted that pharmacists should become more engaged in solving health-care problems.[21] RBL leads to logical thinking through real practice and observation[22] and fosters advancement and development of pharmacy students in their increasingly diverse profession to meet future health-care demands.[23] Our RBL approach is transferable to other health science courses without committing additional physical resource, such as nursing.[24] Similarly, it is used in geography[25] and after-school program for high school students.[26]

RBL has operational challenges. Participative style group work is more acceptable when a lesson plan is presented well before implementation. Interest is maintained by allowing time for students to reach considered conclusions. Experience gained from this study showed that planning for an optimal group size per facilitator is important to the RBL experience. Easy access to teaching materials including online resources and class time devoted to reviewing prior knowledge then allows students to focus on the RBL task.

This study has limitations. Its quasi-experimental design threatens internal validity due to the lack of a control group. Teaching within the existing curriculum compressed the pre- and post-test interval (2 weeks), therefore, only assessed short-term benefits contrary to long-term learning and skills acquisition of RBL. This time window was squeezed because the study intended to evaluate potential benefits of RBL but wider applications need to overcome time restraints. Since RBL aims at lasting learning and skills acquisition applicable to their professional lives well after graduation, but needs continuity. Nevertheless, the study has some merit, especially real research into a major problem in pharmacy (non-adherence), an objective end point, the post-test, and a dedicated questionnaire.

In most teaching research, running a two-arm randomized experimental study may not be ethical. Even if possible, both teachers and students are not blinded to the intervention. Alternatively, a randomized cross-over controlled study where each group is treated equally with standard teaching method (lecture) should overcome the major ethical objection while carefully structured testing is a more objective form to assess learning. Student questionnaires should clearly focus on the learning method and bear no relation to the currently standardized format that assesses the teaching process. This type of RBL incurred higher costs for teacher preparation time and analyses and supervision of students.[27,28] However, compared to laboratory teaching, RBL is cheaper, particularly for physical infrastructure.

Another challenge was that RBL outcomes used an assessment method reflecting didactic teaching while a rationale for RBL was acquisition of skills and deeper understanding that needs dedicated assessments. At present, teachers and students focus on information and grades that will quickly become obsolete in a rapidly evolving world while skills are enduring and hence RBL more efficacious. Teaching and assessment should reflect this trend. Although our study may help shift training toward this direction, it requires adoption by other teachers and validating bodies: The Thai Pharmaceutical Council encourages "active learning." Nevertheless, a meaningful, real-life project with parental/family involvement, as delivered, can positively influence student learning.[29]

CONCLUSIONS

RBL has a promising impact on student knowledge and teaching assessment. For further study, more complex protocols that investigate the role of RBL in skill acquisition are needed to overcome ethical, timetable, and design constraints.

AUTHORS' CONTRIBUTIONS

"Conceptualization, C.K.; Methodology, C.K. and S.C.; Data Analysis, P.M.; Data interpretation and Writing-Original Draft Preparation, C.K., C.M., and T.S.; Writing-Review and Editing, C.K., C.M., T.S., and N.S.; and Supervision, C.K. All authors read and approved the final manuscript."

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Ahdika A. Improvement of quality, interest, critical, and analytical thinking ability of students through the application of research based learning (RBL) in introduction to stochastic processes subject. Int Electron J Math Educ 2017;12:167-91.
2. Diezmann C, Stevenson M, Fox J. Supporting exceptional

students to thrive mathematically. In: Perry B, Lowrie T, Logan T, MacDonald A, Greenlees J, editors. Research in Mathematics Education in Australasia 2008-2011. Rotterdam: Sense Publishers; 2012. p. 89-109.
3. Nuchwana L. How to link teaching and research to enhance students' learning outcomes: Thai university experience. Procedia Soc Behav Sci 2012;69(Suppl C):213-9.
4. Wannapiroon P. Development of research-based blended learning model to enhance graduate students' research competency and critical thinking skills. Procedia Soc Behav Sci 2014;136:486-90.
5. Healey M. Linking research and teaching to benefit student learning. J Geogr High Educ 2005;29:183-201.
6. Blackmore PF, Fraser M. Researching and teaching: Making the link. In: Blackwell PB, editor. Towards Strategic Staff Development in Higher Education. Maidenhead, UK: McGraw-Hill International; 2007. p. 131-41.
7. Blume S, Madanchi N, Böhme S, Posselt G, Thiede S, Herrmann C. Die lernfabrik research-based learning for sustainable production engineering. Procedia CIRP 2015;32:126-31.
8. Srikoon S, Bunterm T, Samranjai J, Wattanathorn J. Research synthesis of research-based learning for education in Thailand. Procedia Soc Behav Sci 2014;116:913-7.
9. Atkinson J, De Paepe K, Pozo AS, Rekkas D, Volmer D, Hirvonen J, *et al*. The second round of the PHAR-QA survey of competences for pharmacy practice. Pharmacy (Basel) 2016;4:E27.
10. Storm B. Pharmacoepidemiology. New York: Wiley; 2000.
11. Rothman K, Greenland S. Modern Epidemiology. Philadelphia, PA: Lippincott-Raven; 2000.
12. Kongkaew C. Principles of Promoting Medication Adherence. Bangkok: Chulalongkorn University Press; 2018.
13. Tuan HL, Chin CC, Tsai CC, Cheng SF. Investigating the effectiveness of inquiry instruction on the motivation of different learning styles students. Int J Sci Math Educ 2005;3:541-66.
14. Karaçalli S, Korur F. The effects of project-based learning on students' academic achievement, attitude, and retention of knowledge: The subject of "Electricity in our lives". Sch Sci Math 2014;114:224-35.
15. Sumbawati MS, Anistyasari Y. The impact of research-based learning on student's academic performance and motivation. IOP Conf Ser Mater Sci Eng 2018;296:012043.
16. Sota C, Peltzer K. The effectiveness of research based learning among master degree student for health promotion and preventable disease, faculty of public health, Khon Kaen university, Thailand. Procedia Soc Behav Sci 2017;237:1359-65.
17. Hardway CL, Stroud MJ. Using student choice to increase students' knowledge of research methodology, improve their attitudes toward research, and promote acquisition of professional skills. Int J Teach Learn High Educ 2014;26:381-91.
18. Dhaqane M. Satisfaction of students and academic performance in Benadir university. J Educ Pract 2016;7:59-63.
19. Kongkaew C, Methaneethorn J, Mongkhon P, Dechanont S, Taburee W. Drug-related problems identified at patients' home: A Prospective observational study in a rural area of Thailand. J Patient Saf 2017. DOI: 10.1097/PTS.0000000000000404.
20. Dechanont S, Jedsadayanmata A, Butthum B, Kongkaew C. Hospital outpatient visits associated with medication-related problems in thailand: A Multicenter prospective observational study. J Patient Saf 2017. DOI: 10.1097/PTS.0000000000000367.
21. World Health Organization. The Role of the Pharmacist in the Health Care System, Preparing the Future Pharmacist: Curricular Development: Report of a Third WHO Consultative Group on the Role of the Pharmacist. Vancouver: World Health Organization; 1997.
22. Friesen S, Scott D. Inquiry-Based Learning: A Review of the Research Literature; 2017. Available from: http://www.galileo.org/focus-on-inquiry-lit-review.pdf. [Last accessed on 2019 Nov 15].
23. International Pharmaceutical Federation. FIP Education; 2017. Available from: http://www.fip.org/pharmacy_education. [Last accessed on 2019 Nov 15].
24. Stevens KR. The impact of evidence-based practice in nursing and the next big ideas. Online J Issues Nurs 2013;18:4.
25. Al-Maktoumi A, Al-Ismaily S, Kacimov A. Research-based learning for undergraduate students in soil and water sciences: A case study of hydropedology in an arid-zone environment. J Geogr High Educ 2016;40:321-39.
26. Holstead J, King MH, Miller A. Research-based practices in afterschool programs for high school youth. After Sch Matters. 2015;21:38-45.
27. Cutrim EM, Rudge D, Kits K, Mitchell J, Nogueira R. Changing teaching techniques and adapting new technologies to improve student learning in an introductory meteorology and climate course. Adv Geosci 2006;8:11-8.
28. Wang MT, Sheikh-Khalil S. Does parental involvement matter for student achievement and mental health in high school? Child Dev 2014;85:610-25.
29. Fan X, Chen M. Parental involvement and students' academic achievement: A meta-analysis. Educ Psychol Rev 2001;13:1-22.
30. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. Med Care 1986;24:67-74.