การเรียนรู้ตลอดชีวิตสำหรับทักษะการวิจัย: ลักษณะเฉพาะของหลักสูตรดุษฎีบัณฑิตนานาชาติ วิศวกรรมศาสตร์เภสัชกรรม

Lifelong Learning for Research Skills: An Exclusive Feature of the Ph.D. International Program in Pharmaceutical Engineering

นิพนธ์ต้นฉบับ **Original Article**

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บทคัดย่อ

วัตถุประสงค์: เพื่อ 1) ศึกษาสภาพ ปัญหา ความต้องการ ของนักศึกษาหลักสูตรปรัชญาดุษฎีบัณฑิต สาขาวิชาวิศวเภสัชกรรม (หลักสูตรนานาชาติ) มหาวิทยาลัยศิลปากร เกี่ยวกับการพัฒนาทักษะการวิจัย 2) นำเสนอแนวทางและออกแบบวิธีการจัดการเรียนรู้ตลอดชีวิตเกี่ยวกับการพัฒนาทักษะการวิจัยที่เหมาะสม **วิธีการศึกษา:** การวิจัยและพัฒนานี้ดำเนินการในช่วงสิงหาคม 2566 ถึงตุลาคม 2567 แบ่งเป็น 4 ขั้นตอน ได้แก่ 1) วิเคราะห์สภาพ ปัญหา และความต้องการ 2) สร้างกรอบแนวคิดจากข้อสรุป 3) พัฒนาแนวทางการเรียนรู้ตลอดชีวิต และ 4) ทดลองใช้ เลือกตัวอย่างแบบเจาะจง ประเมินผลด้วยสถิติเชิงพรรณนาและประเมินความพึงพอใจ 5 ระดับ **ผลการศึกษา: A**) พบสภาพ ปัญหา และความต้องการ จากการศึกษาเอกสารและสนทนากลุ่ม 8 คน ที่เลือกจากผู้บริหาร อาจารย์ ศิษย์เก่า และนักศึกษา **B**) กำหนดองค์ประกอบที่เกี่ยวข้องกับความรู้และทักษะด้านการวิจัยได้ 4 องค์ประกอบ คือ ความสามารถด้านวิธีการวิจัย ด้านการใช้ภาษาอังกฤษ ด้านการนำเสนอ และด้านการจัดการความเครียด ตามลำดับ โดยผู้เชี่ยวชาญ 3 คนเห็นว่าด้านวิธีการวิจัยสำคัญที่สุด **C**) พัฒนาแนวทางการเรียนรู้ตลอดชีวิต โดยมุ่งเน้นการเรียนรู้ด้านวิธีการวิจัยเป็นทักษะสำคัญ โดยใช้ “สัญญาการเรียนรู้” 6 ขั้นตอน คือ ตั้งเป้าหมายการเรียนรู้ (Goals) พิจารณาดูข้อมูล (Investigation) เพิ่มพูนการฝึกฝน (Practice) สะท้อนผลการเรียนรู้ (Reflect and Evaluate) นำไปสู่การปรับปรุงและพัฒนา (Improve and development) สรรหาประโยชน์เพื่อใช้จริง (Share and Contribute) ผู้ทรงคุณวุฒิเห็นว่าทุกขั้นตอนเหมาะสมและมีคุณภาพในระดับมากที่สุด **D**) ทดลองใช้กับนักศึกษาในหลักสูตร 5 คน สัญญาการเรียนรู้เพื่อพัฒนาทักษะการวิจัยสอดคล้องกับหลักสูตรและความรู้ความเข้าใจของนักศึกษาร้อยละ 96.00 ความพึงพอใจต่อการใช้สัญญาการเรียนรู้มีค่าเฉลี่ย 4.77 ซึ่งอยู่ในระดับมากที่สุด **สรุป:** สัญญาการเรียนรู้ 6 ขั้นตอนช่วยพัฒนาความสามาถในการเรียนรู้ และควรใช้เพิ่มความสามารถในด้านภาษาอังกฤษ การนำเสนอ และการจัดการความเครียด

คำสำคัญ: การเรียนรู้ตลอดชีวิต; ทักษะการวิจัย; สาขาวิศวเภสัชกรรม; สัญญาการเรียนรู้

Abstract

Objective: To 1) determine study conditions, problems, and needs of Ph.D. in Pharmaceutical Engineering (International Program) students (Silpakorn University) regarding research skill development and 2) develop guidelines and design on research skill development. **Method:** This research and development project was conducted August 2023 to October 2024 and divided into four steps: 1) analyzing current situation, problems, and needs, 2) creating conceptual framework, 3) constructing lifelong learning model, and 4) implementing and evaluating model in purposively selected participants. Data analyzed via descriptive statistics and 5-point satisfaction rating. **Results: A**) Key problems and needs were identified by document reviews and focus group of 8 participants (administrators, lecturers, alumni, and current students). **B**) Four core components of research knowledge and skills were defined: (1) research methodology skills, (2) English language proficiency, (3) presentation skills, and (4) stress management, which research methodology being most important, confirmed by three experts. **C**) Lifelong learning approach was developed with an emphasis on research skills, using a six-step "Self-directed Learning Contract" model along with: 1) set learning goals (Goals), 2) investigating resources and information (Investigation), 3) increasing practicing skills (Practice), 4) reflecting on and evaluating learning outcomes (Reflect and Evaluate), 5) improving and developing further (Improve and Development), and 6) Sharing and contributing knowledge (Share and Contribute). The 6-steps model exhibited the highest appropriateness and excellent quality evaluated by three experts. **D**) Model implementation with five doctoral students revealing self-directed learning contract effectively enhanced students' research skills in alignment with curriculum. Students demonstrated 96% understanding of materials and the highest level of satisfaction with self-directed learning contract (mean = 4.77). **Conclusion:** Six-steps of “Self-directed Learning Contract” model enhanced relevant competencies, utilization of English proficiency, presentation skills, and stress management.

Keywords: lifelong learning; education; research skill; Pharmaceutical Engineering program; learning contract

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Introduction

Doctor of Philosophy Program (Ph.D.) in Pharmaceutical Engineering (International Program), Faculty of Pharmacy, Silpakorn University is designed to generate doctoral graduates who are both creative thinkers and competent in

integrating knowledge and technology across multidisciplinary domains of pharmaceutical technology and engineering. The program objective emphasizes research-driven innovation to generate new bodies of knowledge through the synthesis of interdisciplinary expertise. Graduates are expected to meet the evolving demands of employers and the labor market, particularly within the pharmaceutical manufacturing industry and related sectors. Furthermore, the curriculum is aligned with the academic quality standards prescribed by the Office of the Higher Education Commission. Ph.D. in Pharmaceutical Engineering (International Program) prepares students in the fulltime learning program based on assessment according to curriculum plan through research courses up to 72 credits of dissertation along with the development of learning skills and necessary life skills for the whole 5-years program.[1] In addition to learning courses, Asian University Network Quality Assurance (AUN-QA) has emerged as a promising approach for this Ph.D. program to ensure the quality assurance system for overall academic standards.

Faculty of Pharmacy at Silpakorn University offers graduate-level programs, including Doctor of Philosophy (Ph.D.) degrees. Its focus lies in producing graduates equipped with knowledge, ethics, and a sense of responsibility to fulfill the missions of the pharmaceutical profession, both in the public and private sectors. The faculty places great emphasis on combining knowledge and skills to maximize the benefits derived from teaching and learning. In addition to education, the Faculty of Pharmacy actively engages in research and development of pharmaceuticals and related fields, as well as providing academic services to both public and private communities. Ph.D. in Pharmaceutical Engineering (International Program) has established collaborations with leading universities worldwide, particularly in the field of pharmacy.[4] Instructional activities emphasize a variety of learning process designed to enhance self-development potential. This Ph.D. program fosters participation along with student-centered learning aimed at problem-solving for generating new knowledge and innovations. This purpose is expected to engage in experiential learning to stimulate essential “research skills” to support academic growth abs to prepare students for practical application in professional setting upon graduation. Moreover, this Ph.D. program deems “research skill” to be the foundation for lifelong learning skill of students.

Lifelong learning has been found on the belief of human learning as a continuous and evolving process. Lifelong learning is not confined to classrooms or traditional teaching form of instruction. Rather, it is shaped by an individual process of genuine curiosity and passion for learning across the lifespan.[2] Lifelong learning becomes a dynamic integration of science and art according to personal growth and self-cultivation to confront and navigate life’s complex challenges through deep understanding process. This phenomenon is referred to as “ wisdom.” [3] A forming knowledge insight is persuaded and deeply ingrained in oneself. It involves individual’s unique desire to acquire knowledge.[4] This is a process of knowledge acquisition is self-directed learning (SDL) which is to empower persons to realize their full potential across all dimensions of human development.

In this research on the lifelong learning for research skills in the Ph.D. International Program in Pharmaceutical Engineering of Silpakorn University, we postulated that there are vital indicators of academic and professional success. There are complexities that necessitate deeper understanding of needs and contextual constraints. This research aimed to develop guidelines for lifelong learning model to empower research skill for the international doctoral context. Specifically, we aimed to 1) identify conditions, problems, and needs of Ph.D. in Pharmaceutical Engineering (International Program) students regarding research skill development, and 2) develop guidelines and design on research skill development appropriate for lifelong learning model suitable for these students.

Methods

This research and development (R&D) project on the Ph.D. International Program in Pharmaceutical Engineering of Silpakorn University was conducted from July 2021 to June 2022. We divided the whole process into four steps follows. In the **first step**, we conducted document search to review information relevant to analysis and synthesis of the study framework, key problems and needs were identified for further focus group. Focus group discussion was carried out with eight participants comprising administrators, lecturers, alumni, and current students through purposive sampling. Specific curriculum requirements are shown in Table 1.

Table 1 Course learning outcomes (CLOs), program learning outcomes (PLOs), and measurement.[12]

Course learning outcomes (CLOs), program learning outcomes (PLOs), and measurement
CLO 1: Demonstrate self-discipline and courtesy. **PLO 1.1:** Express self-discipline, punctuality, and responsibility. **Measurement:** Observe, Lab meeting
CLO 2: Articulate interpersonal skills and be responsible for own assignment and as a group. **PLO 4.2:** Take full responsibility for own activities and as a group. **Measurement:** Assignment, Group activity, Lab meeting
CLO 3: Reinforce analytical and critical thinking skills in a systematic and reasonable approach. **PLO 3.4:** Demonstrate ability to draw logical conclusions & implications from analysis of an issue or research problem. **Measurement:** Independent research, Discussion, Research findings, Lab meeting
CLO 4: Exploit a variety of technologies & software for calculation, searching information, communication, and other benefits for research. **PLO 5.3:** Use a wide range of available numerical, information, and communication technologies. **Measurement:** Assignment, Research results presentation, Lab meeting
CLO 5: Conduct, communicate, disseminate research work within restrictions of academic, professional, and research code of conduct. **PLO 1.2:** Demonstrate ethical awareness and the ability to conduct research work conformed to the code of ethics for researcher of the National Research Council of Thailand. **Measurement:** Advice, Independent research work, Presentation, Lab meeting
CLO 6: Judiciously arrange the time frame to complete research within the curriculum study plan. **PLO 1.1:** Express self-discipline, punctuality, and responsibility. **Measurement:** Discussion, Questionnaire, Lab meeting
CLO 7: Ascertain, accumulate, analyze, and evaluate research information from commonly used sources in Pharmaceutical Engineering and related fields, including literature & patent databases. **PLO 3.1:** Search, analyze, summarize, and/or evaluate information in Pharmaceutical Engineering **Measurement:** Advice, Assignment, Lab meeting
CLO 8: Systematically and theoretically analyze information to explore and formulate a strategic research topic, objectives, and research questions; clearly establish principles and reasons for performing research as well as benefits of research outcomes. **PLO 3.3:** Systematically develop good research question/topic & select instruments & tools for conduct research works. **Measurement:** Assignment, Discussion with advisor, Lab meeting
CLO 9: Set up a scope of research and design a research project for problem-solving, creating innovation or new knowledge in Pharmaceutical Engineering. **PLO 2.2:** Design a novel means for solving the research problems in industries or create the novel knowledge in Pharmaceutical Engineering (creativity). **Measurement:** Searching information, Assignment, Discussion, Lab meeting
CLO 10: Integrate pharmaceutical, engineering, and related knowledge for designing a complete research proposal/ project, conducting an experiment, and concluding research results. **PLO 2.1:** Integrate interdisciplinary knowledge, including pharmaceutical and engineering, for solving research problems **Measurement:** Assign for research proposal, Independent research work, Presentation of research results
CLO 11: Apply Pharmaceutical Engineering knowledge and skills for conducting research to legitimately solve industrial problems or generate innovation or novel knowledge in Pharmaceutical Engineering. **PLO 2.2:** Design novel means for solving research problems in industries or create novel knowledge in Pharmaceutical Engineering (creativity) **Measurement:** Advice, Independent research work, Discussion, Lab meeting
CLO 12: Effectively introduce, evaluate, and utilize mathematical and statistical data. **PLO 5.1:** Apply mathematics and statistics for evaluating research data. **Measurement:** Presentation of data, Discussion, Lab meeting
CLO 13: Analyze and interpret data both quantitatively and qualitatively. **PLO 5.2:** analyze and interpret data both quantitatively and qualitatively. **Measurement:** Discussion, Presentation, Lab meeting
CLO 14: Efficiently communicate, clarify, and transfer concepts, knowledge, and innovation from research results to various targeted groups. **PLO 5.4:** Demonstrate the ability to communicate with academic audiences through speaking, listening, and writing research reports, including thesis and journal publication. **Measurement:** Presentation, Group Discussion, Lab meeting
CLO 15: Forcefully propose research results in forms of dissertation, research article or abstract and oral presentation. **PLO 5.4:** Demonstrate the ability to communicate with academic audiences through speaking, listening, writing research reports, including thesis and journal publication. **Measurement:** Advice, Thesis defense, Presentation, Lab meeting
CLO 16: Appropriately select various forms of communication technologies for research results presentation. **PLO 5.5:** Demonstrate attractive presentation through the use of body language, tone of voice, presentation slides, or **Measurement:** Visual aids. Presentation, Discussion, Answer questions, and Lab meeting

Note: Data were related to teaching strategies-based issues of the Thesis course.

In the **second step**, a conceptual framework was created. We defined core components of research knowledge and skills relevant to the Ph.D. International Program in Pharmaceutical Engineering" curriculum and pharmaceuticals academic related fields along with lifelong learning style on research skill. Participants were concerned about program benefits and yet did not abandon them until successful. Data were verified by three experts in higher education.

The **third step** was to construct the **lifelong learning model. The quality of lifelong learning** was **developed by 5 assumptions of lifelong learning concepts** specifically self-concept, learner experience, readiness to learn, orientation to learn, and motivation to learn. Lifelong learning approach was developed with an emphasis on research skills using step construction learning model designed and evaluated by three experts in higher education.

The **fourth step** was the construction of a lifelong learning model for Ph.D. International Program in Pharmaceutical Engineering students. The model was implemented and evaluated in give students selected by a purposive sampling**.** Data were analyzed by descriptive statistics and a 5-point satisfaction rating scale.

Results

In this R&D project, the process was completed for the objectives of 1) the study of conditions, problems, and needs of Ph.D. in Pharmaceutical Engineering (International Program) students regarding research skill development and 2) the development of guidelines and design on research skill development appropriate for lifelong learning model. Results from the study's four steps are as follows.

In the **first step**, the document review, analysis and synthesis and the subsequent focus group of eight participants (i.e., administrators, lecturers, alumni, and current students) identified situations, problems, and needs of the students. These findings were validated by three experts. The situation, problems, and needs were synthesized into a conceptual framework. There were four essential components emerging including 1) research skill knowledge, 2) the international program need was English proficiency skill, 3) research presentation skills, and 4) stress management skill. Of these four components, the focus group and three experts

unanimously agreed that the most crucial need for lifelong learning strategy was research skill knowledge (Table 2).

Table 2 Essential needs of Ph.D. in Pharmaceutical Engineering (International Program).

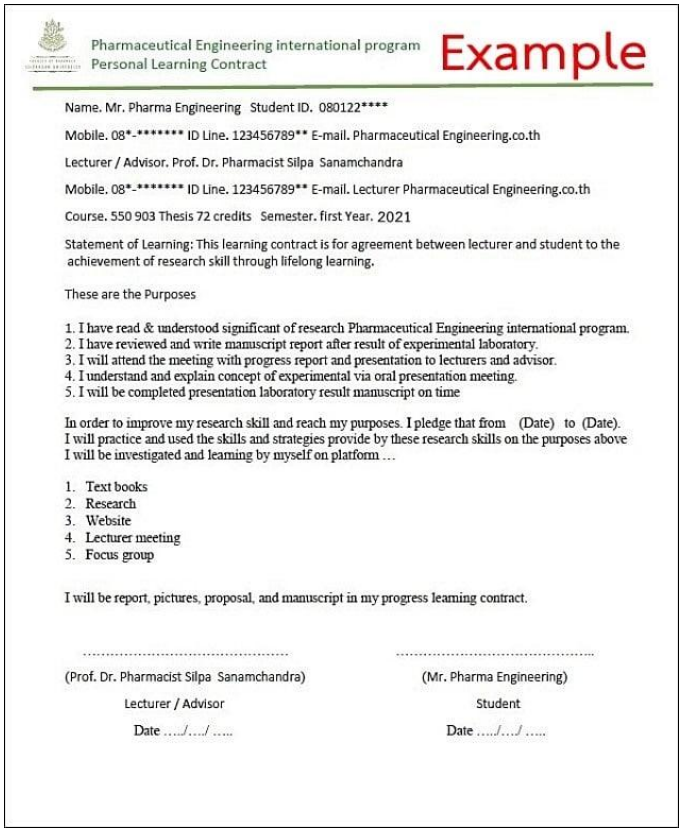
Needs of Ph.D. in Pharmaceutical Engineering (International Program)	Rank
Research skills knowledge	1
English proficiency skills	2
Research presentation skills	3
Stress management skills	4
Others (scholarship for Ph.D. student, Computer, Laptop, etc.)	5

In the **second step**, the developed **c**onceptual framework was based on the five assumptions of lifelong learning including **self-concept, learner experience, r**eadiness **to learn, orientation to learn,** and **motivation to learn.** These reflect the essential needs and challenges faced by international doctoral students. Consensus of research skill as the first significant skill by three experts confirmed that research knowledge is the most critical area of Ph.D. in Pharmaceutical Engineering (International Program) , supporting the lifelong learning strategy emphasized in the path of knowledge (Figure 1).

Figure 1 Conceptual frame work of lifelong learning on research skill.

In the **third step**, the **lifelong learning model** was developed with an emphasis on research skills. The model consisted of six steps of self-directed lifelong learning called "Self-directed Learning Contract" model namely 1) setting learning goals (Goal setting), 2) investigating resources and information (Investigation), 3) increasing practicing skills (Practice), 4) reflecting on and evaluating learning outcomes (Reflection and Evaluation), 5) improving and developing further (Improvement and Development), and 6) Sharing and contributing knowledge (Sharing and Contribution). The 6 steps of "Self-directed Learning Contract" were considered highly appropriate and of excellent quality as reviewed and evaluated by the three experts (Figure 2,3).

Figure 2 Self-directed Learning Contract process of lifelong learning.


Pharmaceutical Engineering international program
Personal Learning Contract

Example

Name. Mr. Pharma Engineering Student ID. 080122****

Mobile. 08*-******* ID Line. 123456789** E-mail. Pharmaceutical Engineering.co.th

Lecturer / Advisor. Prof. Dr. Pharmacist Silpa Sanamchandra

Mobile. 08*-******* ID Line. 123456789** E-mail. Lecturer Pharmaceutical Engineering.co.th

Course. 550 903 Thesis 72 credits Semester. first Year. 2021

Statement of Learning: This learning contract is for agreement between lecturer and student to the achievement of research skill through lifelong learning.

These are the Purposes

1. I have read & understood significant of research Pharmaceutical Engineering international program.
2. I have reviewed and write manuscript report after result of experimental laboratory.
3. I will attend the meeting with progress report and presentation to lecturers and advisor.
4. I understand and explain concept of experimental via oral presentation meeting.
5. I will be completed presentation laboratory result manuscript on time

In order to improve my research skill and reach my purposes. I pledge that from (Date) to (Date). I will practice and used the skills and strategies provide by these research skills on the purposes above I will be investigated and learning by myself on platform …

1. Text books
2. Research
3. Website
4. Lecturer meeting
5. Focus group

I will be report, pictures, proposal, and manuscript in my progress learning contract.

…… ……

(Prof. Dr. Pharmacist Silpa Sanamchandra) (Mr. Pharma Engineering)

Lecturer / Advisor Student

Date …./…./ ….. Date …./…./ …..

Figure 3 Example of Learning Contract process for research skill.

In the **fourth step**, the implementation and evaluation of the self-directed learning contract (Figure 3) with five students resulted in 96% of them demonstrating clear understanding in measurement. The overall satisfaction score mean was 4.77 within a standard deviation of 0.46 out of 5 points indicating of the highest overall satisfaction. All five domains of satisfaction were found to be also at the highest level (Table 3).

Table 3 Satisfaction with self-directed learning contract (N = 5).

Satisfaction with …	Mean	S.D.	Meaning
1. self-directed learning contract	4.82	0.53	Highest
2. process of self-pacing construction knowledge	4.78	0.41	Highest
3. learning management of research skills	4.72	0.48	Highest
4. learning according to one's own abilities'	4.77	0.45	Highest
5. result of self-directed learning contract	4.78	0.45	Highest
Total	4.77	0.46	Highest

Discussions and Conclusion

The research "Lifelong Learning for Research Skills: An Exclusive Feature of the Ph.D. International Program in Pharmaceutical Engineering" addressed 2 objectives namely the determination of conditions, problems, and needs of the students and the development of the guidelines and design on research skill development appropriate for lifelong learning for the students. This research employed research and development methodology (R&D). Findings of this research reflected the importance of lifelong learning as a key element in developing research skills among students in the Doctor of Philosophy (Ph.D.) in Pharmaceutical Engineering (International Program).[4] The study revealed that students face multiple challenges in their research journey in relation to the CLOs[5] particularly in the research skills knowledge to enhance the students' thesis skills. Prior to the thesis course registration, students were encouraged to conduct an independent study with the content related to their thesis topic.[6] They were also supported for their performance in English proficiency, research presentation skills, and stress management. These aspects were aligned with both the academic demands of the program and the real-life context of international doctoral study. These aspects also highlighted the need for a structured and flexible learning model that could help lecturers and advisors to better facilitate the support for students.[7] The construction of the "Self-Directed Learning Contract" model based on lifelong learning principles successfully addressed these challenges. This lifelong learning enables students to respond to the need for continuous improvement in their learning journey, especially in the face of rapidly changing learning behavior.[8]

Self-Directed Learning Contract was conducted on six key steps namely 1) goal setting, 2) investigation, 3) practice, 4) reflection and evaluation, 5) improvement and development, and 6) sharing and contribution. These steps together promote self-direction, accountability, and continuous development. This reflects Knowles' assumptions of adult learning driven by internal goals, enthusiasm students exhibit motivation to learn, driven by their internal maturity and motivation.[9] Lifelong learning abilities are inherent in the qualification standards and research competencies of graduated students. Program lecturers play a crucial role in cultivating the attitude of graduated students towards lifelong learning skills, encouraging them to tap into their potential as students approach their studies with a growth mindset.[10] Lifelong learning is seen as a skill that empowers and guides students in managing all aspects of their research skills. The development of research skills through lifelong learning is facilitated by the program's curriculum lecturers and advisor mentorship.[11]

The implementation of the model showed promising results. Satisfaction levels across all areas were consistently at the highest level, with an overall mean of 4.77 (S.D. = 0.46) out of 5 points. Notably, the highest satisfaction score was found in the general use of the self-directed learning contract (mean = 4.82), followed closely by satisfaction in constructing knowledge at one's own pace (mean = 4.78). These findings emphasize that doctoral students value autonomy and personalized learning experiences, which the model effectively supports. Furthermore, the strong emphasis on research knowledge as the most critical skill, confirmed by expert consensus, highlights the importance of aligning learning models with practical and academic needs of students in the Ph.D. in Pharmaceutical Engineering (International Program). This ensures that students are progressing in their learning and research activities in line with the program's standards and expectations. By actively considering the various dimensions of the program and employing effective strategies, the lecturers and advisors contribute to the overall success and effectiveness of Pharmaceutical Engineering international program.[12] By using self-directed learning habits and providing a clear framework for skill development, the model empowers students to take control of their learning processes along with meeting the lifelong learning settled in Ph.D. Pharmaceutical Engineering (International Program) curriculum. By incorporating these specific learning skills into the curriculum, the program aims to ensure that the graduated students actively engage with the materials and develop the necessary skills and competencies required in the field.[13,14]

Research skills through lifelong learning strategies are an integral part of the curriculum, encompassing both generic and specific abilities. The program defines several PLOs that reflect the desired outcomes for graduates.[12,15]

PLO1[12] (1.1, 1.2) focuses on “Ethics and morality” as a generic outcome. It emphasizes the graduates’ ability to demonstrate self-discipline, punctuality, and responsibility. Graduates are also expected to exhibit ethical awareness and conduct research work in accordance with the ethical codes set by the National Research Council of Thailand. Through the lifelong learning process, learners develop a sustained commitment to ethical awareness and integrity, enabling them to conduct research responsibly and adhere strictly to the ethical standards prescribed by the National Research Council of Thailand. The purpose of lifelong learning is to cater to the abilities of adults, as it enables individuals to envision their own self-development and pursue further education according to their independent and flexible needs.[16]

PLO2[12] (2.1, 2.2) pertains to specific outcomes in pharmaceutical engineering knowledge. Graduates are expected to integrate interdisciplinary knowledge including solving research problems, and designing innovative solutions in the pharmaceutical engineering field, demonstrating creativity. This alignment reflects the learner’s ability to continuously explore, acquire, and apply scientific and engineering concepts to solve complex research problems. Through a sustained commitment to learning, graduates demonstrate creativity and innovation in designing pharmaceutical solutions that respond to contemporary challenges.[17]

PLO3[12] (3.1, 3.3, 3.4) addresses competency and cognitive skills in research and problem-solving. Graduates should be proficient in searching, analyzing, summarizing, and evaluating information in pharmaceutical engineering. They should also possess the ability to develop research questions, select appropriate research tools, and draw logical conclusions from the analysis. Through the continuous cultivation of learning skills, students are trained to independently seek, analyze, and evaluate information. These processes enhance their capacity to formulate relevant research questions, select suitable methodologies, and interpret findings critically, all of which are essential in the field.[17,18]

PLO4[12] (4.2) focuses on interpersonal skills and responsibility. Graduates should be capable of working effectively with individuals from diverse cultural backgrounds and taking responsibility for their own activities and group work. Through Contract Learning, learners set individual and shared goals, take ownership of their responsibilities, and learn to negotiate and reflect within group dynamics. These processes mirror real-world professional environments where working with diverse teams and being accountable for both personal and collective outcomes are essential. As a result, students not only cultivate intercultural competence but also develop ethical responsibility and teamwork skills that align with lifelong growth and sustainable professional practice.[19-22]

PLO5[12] (5.1, 5.3, 5.4, 5.5) encompasses information technology, numerical analytical skills, and communication proficiency in English. Graduates should be adept at applying mathematical and statistical techniques to evaluate research data. They should also possess the skills to analyze and interpret data quantitatively and qualitatively using various numerical, information, and communication technologies. Additionally, graduates should be able to effectively communicate their research findings through speaking, listening, and writing, including the production of research reports, theses, and journal publications. They should also empower students to co-design their own learning trajectories, especially in developing mathematical, statistical, and technological competencies. By identifying individual goals, investigating appropriate resources, engaging in practical skill development, and reflecting on learning outcomes, students sharpen their ability to analyze and interpret both quantitative and qualitative research data with precision and demonstrate effective their research skills and achieve the desired outcome.[15, 23-25]

The Self-Directed Learning Contract model has proven to be an effective tool for cultivating research skills in a lifelong learning context. It supports learners in developing not only academic competencies but also personal growth, adaptability, and long-term professional development—qualities essential for success in a globalized academic environment. Moreover, research skills necessitate dedicated time and effort, along with effective time management skills. Ph.D. students must allocate sufficient time for each stage of the research process.[26] The skill of Self-Directed Learning Contract in research is a significant indicator of whether

students will be able to translate their learning abilities into lifelong practices.[27]

Based on the present study findings and conduct, some suggestions for the applications and further research could be made as follows. The Self-Directed Learning Contract model should be integrated into the Ph.D. Pharmacy curriculum. The six steps of Self-Directed Learning Contract model should be integrated into the Ph.D. in Pharmaceutical Engineering (International Program) students in English language for dissertation proficiency, research presentation skills and students in stress management. For future research, more studies should be conducted across different international programs to generalize the effectiveness of the created model. Future research should examine the long-term impact of the Self-Directed Learning Contract model on research productivity, academic performance, and professional growth.

In conclusion, the Self-Directed Learning Contract model was highly effective in enhancing research skills development of Ph.D. in Pharmaceutical Engineering (International Program) students. The model was based on lifelong learning principles and addressed the specific needs of Ph.D. in Pharmaceutical Engineering (International Program) students, including research knowledge. The implementation of the six-step model resulted in high levels of satisfaction among the participants, with a mean score of 4.77 out of 5 points, indicating strong agreement with the model's relevance and effectiveness. These findings support the idea of Ph.D. in Pharmaceutical Engineering (International Program) students research ability and learner-centered strategies which can significantly enhance students' research academic performance and lifelong learning instincts.[28-33] This highlights the importance of providing support to novice students who may not yet possess the skills to design their own learning goals or know where to find reliable information when faced with a problem.[31] Implementing learning contracts between students and lecturers enhances the evaluation of learning innovations, thereby providing stronger evidence of student learning. Additionally, these discussions underscore the compelling need to equip students with research skills in various areas.

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