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# The survey of learning experience of pediatric injection among registered nurses and nursing students using a design thinking approach

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## Abstract:

**INTRODUCTION:** Pediatric injection is an essential skill of nursing. The survey of the learner's experience during the learning process helps identify problems and leads to improvement. We here applied a three-phase design thinking framework. The study aims to investigate (1) the registered nurses' experience in learning injection technique, (2) the nursing students' experience in learning injection, and (3) the cause of problems and to propose (4) a learning material that will be used to solve the encountered problems.

**MATERIALS AND METHODS:** A cross-sectional study was applied. The study employed convenience sampling. Registered nurses from a tertiary hospital in Bangkok, Thailand, and fourth-year nursing students from a nursing school in Bangkok, Thailand, were selected. The data collecting tools contain a personal information form and the experience of injection learning. The inferential and descriptive statistics was used to analyze the data.

**RESULTS:** The results show that the major issues of injection learning include selecting the correct site for injection and determining the needle length and injection angle and contamination.

**CONCLUSIONS:** Therefore, teaching materials for the anatomy of the injection area and the technique to determine the correct size and depth of injection are needed.

## Keywords:

Design thinking, injection learning, learning experience, nursing education, nursing student

## Introduction

Injection is a drug delivery method using a syringe and needle.<sup>[1]</sup> Various techniques of injection have been developed for different target sites.<sup>[2,3]</sup> The benefits of injections are the administration of drugs, vaccines, and hormones into the human body.<sup>[4]</sup>

The mastery of injection techniques is crucial for learners as it is the key to ensuring the correct and safe administration of medications. Proper technique ensures that children and patients, in general, receive the appropriate medication. Conversely,

incorrect administration can result in several complications for patients, including paralysis, abscesses, infections,<sup>[5]</sup> and sciatic nerve injuries.<sup>[6]</sup> Therefore, learners must possess both the knowledge and skills necessary for the proper administration of injections, as emphasized.<sup>[7]</sup>

Several surveys have examined the perspectives of nurses and nursing students on injection practices. Inadequate knowledge and skills are significant contributors to incorrect injections.<sup>[8]</sup> Nurses and nursing students with limited knowledge often struggle to handle complications during intramuscular injections.<sup>[9]</sup> These complications may arise from various

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aspects of the injection process, such as the procedure for removing the needle at the correct angle, the proper disposal of needles in safety boxes, selection of the appropriate needle size, locating anatomical landmarks,<sup>[10]</sup> choosing the right injection site based on the patient's age group,<sup>[11]</sup> controlling the speed of drug injection, correctly withdrawing the needle, ensuring proper hand hygiene,<sup>[12]</sup> adhering to aseptic principles for all stages of the injection process,<sup>[13]</sup> making informed decisions regarding injection sites, including understanding the correct syringe angle,<sup>[14]</sup> selecting the appropriate muscle based on the size and volume of the administered drug, and monitoring children for any sensory issues at the injection site.<sup>[15]</sup>

The experiences of learners in the context of injection learning are valuable factors to consider in studies. Instructors must understand the specific needs and challenges learners face in the process of learning injection techniques. Moreover, the learning experience is a crucial factor that allows instructors to empathize with and address learners' challenges, ultimately fostering innovation to solve these problems. Therefore, these variables hold significant importance in the study of injection practices.

In the contemporary world, there exist various learning approaches designed to facilitate the teaching of injection techniques in healthcare education. These approaches typically comprise a structured plan that encompasses learning objectives and outlines teaching activities for a given lesson. Notable examples of these approaches include the augmented reality simulation in dental education,<sup>[16]</sup> the Instagram application for educating intramuscular injection in adult patients,<sup>[17]</sup> the poster of intramuscular injection on vastus lateralis site in children,<sup>[18]</sup> the learning objects of intramuscular injection,<sup>[19]</sup> the planned teaching program of intramuscular injection demonstration for second-year nursing students,<sup>[20]</sup> the video recording for undergraduate nursing students to learn totally implantable central venous access ports,<sup>[21]</sup> the low-and-higher-fidelity simulation for subcutaneous and intramuscular injection training of pharmacy students,<sup>[22]</sup> the surrogate patients for practicing injection skill in children,<sup>[23]</sup> the smartphone video of intramuscular injection for nursing students,<sup>[24]</sup> the scenario-based simulation skill training of intramuscular, subcutaneous injection, and intravenous access,<sup>[13]</sup> the flipped learning of subcutaneous injection for Korea nursing students,<sup>[25]</sup> the virtual learning environment of intramuscular injection in adult patients for nursing students,<sup>[26]</sup> and the mobile application of intravenous injection skill for nursing students.<sup>[27]</sup>

Additionally, there are several learning materials pertaining to injections available worldwide, including

the low-cost transcervical laryngeal injection for medical students,<sup>[28]</sup> the simulation model for transcervical laryngeal injection with providing real-time feedback,<sup>[29]</sup> intramuscular injection simulator for nursing students,<sup>[30]</sup> and the low-fidelity model for needle decompression procedure skills.<sup>[31]</sup>

Design thinking is the process of systematically thinking to analyze the users' problems, leading to the development of solutions including service, innovation, or product. This approach is user-centric. The process of design thinking is derived from Stanford Design Thinking's model<sup>[32]</sup> and comprises five steps. Emphasizing the user's problem observes the user's context, background, feelings, and problems in actual situations, aiming to deeply understand the users' problems. It is useful to understand the users' first prior developing solutions. The tools are used for observing the users' problems, including interview, written survey, and recording through photographs or video.

Next, defining the problem specifies the problem based on the observations. Then, ideating the solutions shares ideas from various perspectives to solve the problem. This step helps create ideas and evaluate and select users to solve the selected problem. The fourth step "developing a prototyping" visualizes the idea for solving the problem. Last, "conducting prototype testing" presents a prototype to users. Then, the users give feedback on the importance and usefulness of the prototype.

The design thinking approach is useful for solving the users' problems, because the solutions were based on the understanding of the user's problem in real situation and then defining the problem within the limitation of resources. The brainstorm is the method used for sharing the solution from various perspectives. The last two phrases are developing the prototype, which is the visual idea to solve the problem, and then applied it to the testing phrase to get the users' feedback.

The three phases of the design thinking, the phrase of emphasizing the user's problem, defining the problem, and ideating the solutions, are applied in the study for understanding the learner's problem and/or finding their needs in injection learning, especially for the pediatric group.

In this study, we employ the conceptual framework of design thinking focusing on the process of "emphasizing the users," "defining the problem," and "ideating the solutions." First, emphasizing the user's problem aims to understand the nursing students and the registered nurses' problems in injection learning, and

the questionnaires and interviewing were used as the collecting data tools. Defining the problem, next, identified the problems of the injection learning. One to two problems were selected to be solved depending on the most students' need and on the researcher's time and resources. Ideating the solutions involved the brainstorming phase and generated the solution for the chosen problems. However, subsequent steps, including "developing a prototyping," "conducting a prototype testing," and "assessing and getting feedback," were not included in this report, but will be discussed in further research paper.

Thailand, however, lacks surveys of nursing students' learning experiences in injection teaching, learning needs, and problems. We aimed to investigate the learning experiences of the nursing students and the registered nurses to understand the real problems in teaching and learning in this area. Ultimately, this study would lead to the production of teaching innovations meeting the needs of learners and truly solve the problem of injection teaching and learning.

The purpose of the study aimed to explore (1) students' experiences in injection learning, (2) registered nurses' experiences in injection learning, (3) the causes of problems in injection learning, and (4) learning materials for solving such issues.

## Materials and Methods

### Study design and setting

A cross-sectional study was conducted in this study. The study employed convenience sampling.

### Study participants and sampling

Registered nurses from a tertiary hospital in Bangkok, Thailand, were selected based on the inclusion criteria of having 1–10 years of experience in injection. A total of twenty-one registered nurses participated in the study. Additionally, fourth-year nursing students from a nursing school in Bangkok, Thailand, were selected if they had experience in injection learning. A total of twenty-five nursing students met the inclusion criteria and participated in the study.

### Data collection tool and technique

The step of emphasizing the user's problem was an online survey of the actual injection and injection learning experiences among the registered nurses and fourth-year nursing students, respectively. Due to the COVID-19 pandemic, we used Google Forms for the online questionnaire. The Google Forms were returned within 2 weeks. The descriptive statistic was applied to analyze the data of the study.

The data collecting tool was developed by the researchers. It contains two parts:

1. A personal information form, comprising three items that inquire about gender, age, and position, and one additional item for registered nurses, asking about years of experience in injection.
2. The second part addresses the experience of injection learning and consists

of 14 items, which cover topics, such as the types of pediatric injections learned, actual experiences with pediatric injections, the frequency of pediatric injection learning experiences, traditional injection learning methods, self-confidence in traditional injection learning, its advantages, limitations, suggestions for improvement, preferred traditional learning methods, learning materials for traditional methods, self-confidence in using previous learning materials, their advantages, limitations, suggestions for improvement, additional topics, and supposed difficult topics.

Responses to these items include checklist, open-ended questions, and a rating scale rating ranging from 0 (no confidence) to 10 (highest confidence). The questionnaire underwent validation by three experts, resulting in a content validity index of 0.92.

### Ethical consideration

We collected data, during January–February 2022, using online questionnaires. The research related to human use has complied with all the relevant national regulations and institutional policies, in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' Institutional Review Board or equivalent committee (Mahidol University Central Institutional Review Board, MU-CIRB 2021/450.1910).

## Results

Twenty-one registered nurses in a tertiary hospital, Thailand, and twenty-five 4-year nursing students participated in the convenience sampling. All were females with mean age of 20 years. Their average years of experience of pediatric patients' injection was 5 years. The top four pediatric patients' injection experiences were intramuscular injection (33%), subcutaneous injection (26%), intravenous injection (24%), and intradermal injection (17%).

### Register nurses' experiences in injection learning

Among the registered nurses, we found that the registered nurses have experience in intravenous injection (46%) and intramuscular injection (24%), and the learning experiences of subcutaneous injection and intradermal injection were 50%. The learning experiences

of pediatrics' injection among registered nurses are shown in Figure 1.

Most registered nurses in this study (66.7%) have experience in injection to actual patients in clinical wards since their time as nursing students. However, the remaining (33.3%) did not have experience in injection until they became registered nurses. The most frequent injection's experiences with actual pediatric patients are intramuscular injection (33%) and intravenous (33%), followed the subcutaneous injection (19%) and intradermal injection (15%). The actual experience of pediatrics' injection after they had graduated is shown in Figure 2.

We next compared the percentage between the injection learning experiences of the registered nurses and their experiences in actual patients' injection after graduation [Figure 3]. Some registered nurses did not have experience in any injection techniques in the classroom until they had first-hand experience as a registered nurses. One-third of the registered nurses had actual injection experiences in intramuscular injection after their graduation. However, only 24% had learning experiences of intramuscular injection since they were nursing students. Therefore, nine percentage of them had no experience with intramuscular injection during their time in nursing school.

We found four traditional learning methods of registered nurses: demonstration by instructors (86%), return demonstration or asking the students to show their ability of how to provide an injection (71%), lecturer (48%), and self-study (19%), respectively. The mean self-confidence of them in traditional learning was 6.4 out of 10. The reasons for their confidence were (1) adequate opportunities to practice the pediatrics' injection skill, (2) the learning method of demonstration and return demonstration, and (3) a powerful motivation by instructors that inspired their confidence. However, many students also mentioned that traditional learnings have some limitations. For example, some nursing students did not have opportunities to perform some less common injection techniques on actual patients, such as intradermal injection, which is a rare injection. Learning experience to practice on actual patients was limited due to patients' privacy. The real-life situation also differs from the classroom setting. Moving and crying children make it difficult to control the angle of injection. Moreover, the nursing students suggested that teaching the anatomy of the injection's area and getting feedback during learning should be added to the injection course.

Participants were asked about their desired teaching method. They suggested that their preferred learning method: (1) demonstration of injection techniques

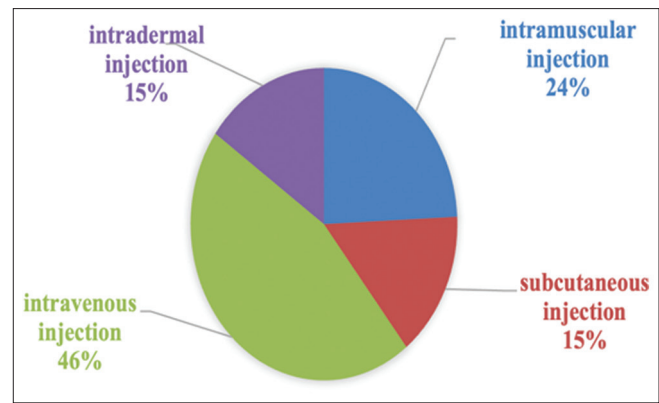


Figure 1: Learning experiences of pediatrics' injection among registered nurses

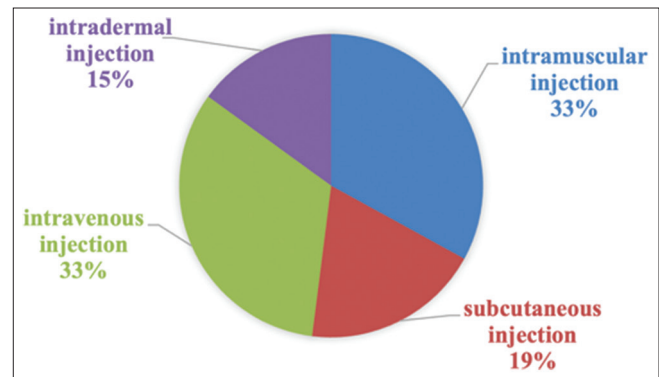


Figure 2: Actual experiences of pediatrics' injection among registered nurses

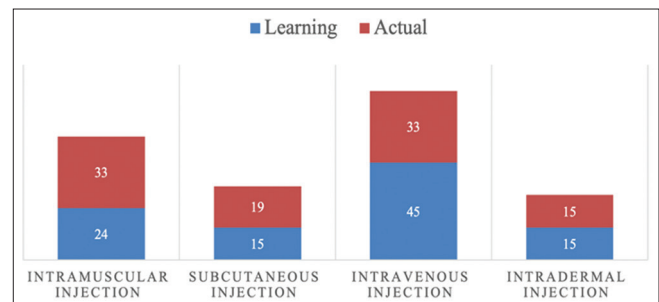


Figure 3: Comparison of the percentages between the injection learning experiences and actual injection experiences after graduation

by instructors and return demonstration or asking the students to show their ability of how to perform injection; (2) the use of simulators and practicing with actual patients, providing conceptual knowledge before practice; and (3) observation of rare pediatrics' injections, such as intravenous injection at the outpatient department. They also suggested that additional learning topics of traditional learning including rare injections, such as intravenous and intradermal injections, are necessary for classroom learning. Learning of anatomy injection's area and getting formative feedback are needed.

The registered nurses learned pediatrics' injection using a simulator (39%) and provided video and YouTube (28%),



electronic learning (17%), website (11%), and social media (2%). After learning the materials, their confidence score was 6.4 out of 10. Their confidence increased due to (1) the clear contents of learning materials, (2) having the ability to repeat the content as they need, and (3) the videos provided a useful for learning conceptual knowledge. Nonetheless, there were an inadequate number of learning materials for all nursing students to practice. The skin of simulators is different from actual patients' skin. However, they preferred online platforms, for example, e-learning, because the students can access anywhere and anytime.

To improve pediatric patients' injection contents, the registered nurses suggest additional topics, including drug calculation, preparing pediatric patients (restraining and selecting injection site and needle size), and the anatomy of pediatric's injection areas for understanding the correct depth, degree, and skin's layer. They informed that the most difficult topics of pediatric injection learning include determining the needle length to the target site (38.1%), determining the degree of injection (33.3%), contamination (9.5%), preparing the pediatric's patients' prior injection (9.5%), and preparing drug and equipment of injection (0%).

### Nursing students' experiences in injection learning

Convenience sampling was used for selecting the samples in the study. Twenty-five nursing students with a mean age of 22 years were involved in this study. All are females. The top four pediatric injection experiences were subcutaneous injection (30%), intramuscular injection (31%), intravenous injection (20%), and intradermal injection (19%), respectively. Among the nursing students, we found that the maximum frequency of pediatric injection was intramuscular injection (40%), subcutaneous injection (35%), intravenous injection (11%), and intradermal injection (19%) [Figure 4].

Most of their injection's experience was the injections to actual patients in clinical wards during their third year of nursing school (80%), whereas other students did not have injection experience. Most frequent injection's experience with actual patients were intramuscular injection (44%), subcutaneous injection (33%), intravenous injection (13%), and the least was intradermal injection (10%). The actual experience of pediatric injection among fourth-year nursing students is shown in Figure 5.

We compare the injection learning experiences of the nursing students and their experiences with actual patients after graduation. Some nursing students did not have any experience in some injection techniques in the classroom until they had first-hand experience

as a registered nurse. 43% of the nursing students had actual injection experiences in intramuscular injection in clinical wards, but only 40% had learning experiences of intramuscular injection in the classroom, indicating that 3% of nursing students had no experience in intramuscular injection before intern in clinical wards. Comparison of the percentages of the learning experience and actual experience in fourth-year nursing students is shown in Figure 6.

This survey shows that there are four traditional learning methods in the classroom, return demonstration (39%), demonstration (27%), lecture (21%), and self-study (13%). The mean self-confidence of nursing students in traditional learning was 7 out of 10. The reasons for

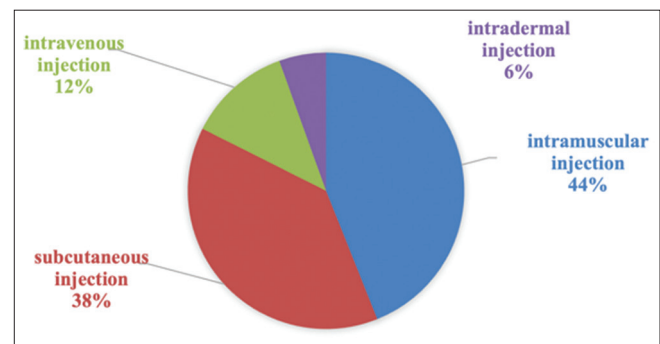


Figure 4: Learning experience of pediatric injection among fourth-year nursing students

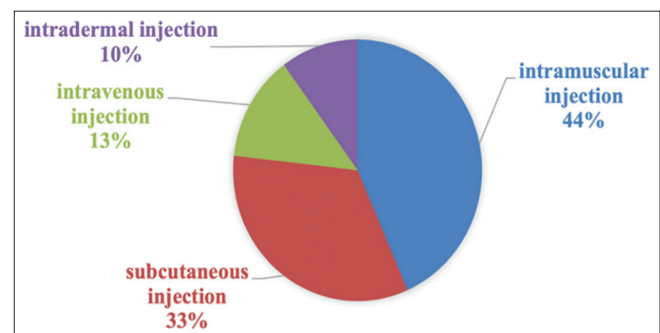


Figure 5: Actual experience of pediatric injections among fourth-year nursing students

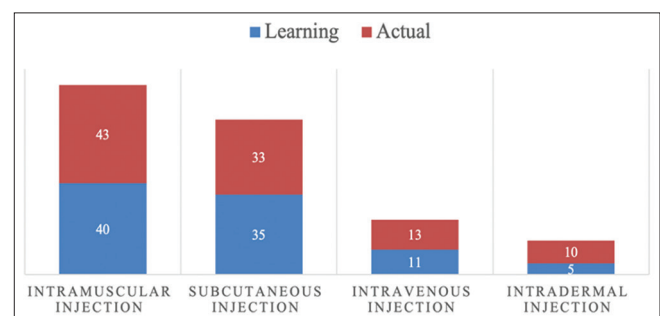


Figure 6: Comparison of the percentages of the learning experience and actual experience in fourth-year nursing students

their confidence were (1) having enough opportunities to practice pediatrics' injection skill, (2) the method of return demonstration helps increase their confidence, and (3) the instructors' encouragement during injection to actual patients. They pointed out that getting formative feedback is important. However, some students did not have experience in injection in actual patients. To enhance their learning, they suggested that they prefer demonstration by instructor in the small group, and the use of cutting-edge learning technology, such as virtual reality, and getting feedback.

In traditional learning, learning materials for pediatric injection include e-learning (32.4%), simulator (31%), provided video and YouTube (29%), website (3%), social media (3%), and application (2%). After learning, the confidence score was 6.7/10. The reasons include (1) receiving appropriate conceptual knowledge before practice, (2) the learning material was easy to access and can be repeated as many as they need, and (3) adequate practicing with simulators to increase their confidence. Nonetheless, the provided videos were not up-to-date, and diverse learning materials, such as PowerPoint slides and full-text paper, were needed. The students also provided suggestions that the simulator should be able to report the pain and injection's depth, and sufficient and portable learning material is necessary.

To improve knowledge of pediatric injection, the students suggested additional topics including the procedure of aspiration before injection, the reason for selecting different sizes of needles, the regulation and prohibition of the injection, and drug usage, especially allergy and side effects. They reported that the most difficult topics of pediatric injection learning were determining the needle length to the target site (32%), contamination (28%), determining the degree of injection (28%), and preparing the pediatrics' patients' prior injection (12%). Additionally, they mentioned that the crying and moving pediatric patients make it difficult to control the degree of injection. We summarize the learning experiences of pediatric injection and their problems among the registered nurses and fourth-year nursing students in the below Table 1.

### Defining the problem

In summary, most experiences of injection learning in both groups were intramuscular, subcutaneous, intravenous, and intradermal injections. To compare the injection learning experience with actual pediatric patients' injections, we found that intramuscular injection skill was taught in the classroom less than the actual experience in both groups when compared to others. Additionally, intramuscular injection and intravenous injection have the highest frequency in the

learning experience for nursing students and registered nurses.

The two popular traditional injection learning methods for both groups were demonstration and return demonstration. The mean score of their self-confidence in traditional learning was 6.4/10 and 7/10 for registered nurses and nursing students, respectively. The advantages of traditional learning include (1) having enough opportunities to practice skills, (2) demonstration and return demonstration are useful learning methods for injection, and (3) instructor's encouragement was impactful for them. However, the actual experiences were different from those in the classroom. There was inadequate practice in injection skills because some students did not have a chance to practice with actual patients, and the real-life situation is different from the classroom learning. Their suggestions are that adding a lecture in the anatomy injection's area and getting feedback during learning would be useful.

The top three learning materials of traditional learning methods in both groups include the simulator model, e-learning, and provided video. The mean score of their self-confidence after these traditional learning materials was 6.4 and 6.7 for registered nurses and nursing students, respectively. The advantages of provided learning materials include (1) clear content, (2) providing video is useful for conceptual learning, (3) the learning material's ability to repeat, (4) the ability of accessible learning materials easily, and (5) adequate practicing with simulator. However, we identified many limitations. The simulator (sponge) was different from the actual patient's skin. The provided video was outdated. Inadequate learning materials were provided for all students. They suggested that the online platform would be a convenient tool, and the simulator's ability should respond to the pain and injection's depth. Additionally, the learning materials should be portable.

The students need extra topics in injection learning including (1) drug calculation, (2) preparing pediatric patients before getting an injection, (3) selecting the injection site and needle size, (4) anatomy of pediatrics' injection area, (5) the rationale for selecting the different sizes of needles, (vi) the regulation and prohibition of the injection, and (vii) drug usage, especially allergy and side effects. They informed me that the top three most difficult topics were determining the needle length and degree of injection, and contamination issue. Their experience and requirements in injection learning are shown in Figure 7.

Based on their experiences and requirements shown in Figure 7, the demonstration and return demonstration

**Table 1: Comparison of injection and learning injection experiences between registered nurses and the 4<sup>th</sup>-year nursing students**

Experience	Samplings	
	Registered nurses	4 <sup>th</sup> -year nursing students
1. Injections learning in pediatric patients	IM > SC > IV > ID	IM, SC > IV > ID
2. Actual pediatric patient injection	IM > IV > SC > ID	IM > SC > IV > ID
3. The top frequency of pediatric injection's learning experience	IV > IM > SC, ID	IM > SC > IV > ID
4. Traditional injection learning methods	Demonstration > return demonstration > lecturer > self-study	Return demonstration > demonstration > lecture > self-study
5. Self-confidence of traditional injection learning and its advantages	$\bar{X}$ =6.4 because (1) having enough opportunities to practice, (2) learning methods, especially demonstration and return demonstration are useful, and (3) instructors' encouragement is powerful	$\bar{X}$ =7 because (1) having enough opportunities to practice skills, (2) demonstration learning method is beneficial, and (3) instructors' encouragement is powerful
6. Limitations of traditional injection learning methods	(1) The real-life situation is different from the classroom and (2) some students have no chance to practice with actual patients	(1) Some students have no chance to practice with actual patients
7. Suggestions for traditional learning method	(1) Learning of anatomy injection's area is necessary and (2) getting formative feedback is necessary	(1) Getting formative feedback is necessary
8. Preferred traditional learning methods	(1) Demonstration, (2) return demonstration, (3) using simulators, (4) practicing with actual patient, and (5) providing conceptual knowledge before practicing, observing some rare pediatrics' injection at OPD	(1) Demonstration in small groups, (2) using high technology, and (3) getting feedback
9. Learning materials for traditional learning methods	Simulator model > provided video and YouTube > e-learning > website > social media	E-learning > simulator model > provided video > website > social media > application
10. Self-confidence in using previous learning material and its advantages	$\bar{X}$ = 6.4 because (1) clear content, (2) providing video is useful for conceptual learning, and (3) the learning material has the ability in repeating	$\bar{X}$ = 6.7 because (1) receiving the conceptual knowledge before practice by watching video, (2) the learning material is easy to access and repeat, and (3) adequate practicing with simulators
11. Limitations of previous learning materials	(1) Simulator (sponge) is different from actual patients and (2) inadequate learning materials	(1) Provided video is not up-to-date
12. Suggestion for previous learning material	(1) Online platform's ability to learn anywhere and anytime	(1) The simulator's ability should respond to the pain and injection's depth and (2) sufficient and portable learning material is necessary
13. Additional topics and contents	(1) Drug calculation, (2) preparing pediatric patients, (3) selecting injection site and needle size and its reasons, and (4) anatomy of pediatrics' injection area	(1) The procedure of aspiration, (2) reasoning of selecting different sizes of needles, (3) regulation and prohibition of the injection, and (4) drug usage especially allergy and side effect
14. The supposed difficult topic	(1) Degerming the needle length, (2) determining the degree of injection, (3) contamination, and (4) preparing patients	(1) Degerming the needle length, (2) contamination, (3) determination of the degree of injection, and (4) preparing pediatric patients

\*IM=intramuscular injection, SC=subcutaneous injection, IV=intravenous injection, ID=intradermal injection

were appropriate learning methods for injection learning. The instructors' encouragement could increase their self-confidence. The provided video enhanced their learning of conceptual knowledge before practical. However, having no chance of practicing with actual patients remains a limitation for learning.

### Ideating the solutions: propose learning materials for the encountered problems

The innovation for pediatric injection learning could mitigate such limitations and meet the recommended requirements. A simulator is one of the learning materials to enhance learners' psychomotor skills, especially one with limited opportunities to practice with real patients in the clinical ward due to the patients' privacy. The

supposed features of the simulator include portability and the ability to provide feedback to learners during learning. Moreover, the taught contents should be added, for example, (1) the anatomy of pediatrics' injection area, (2) selecting the injection's site, (3) determining the needle length, and (4) and determining the degree of injection.

There are several available materials that can give feedback to learners. However, due to the limitation of expertise, cost, and time, the researchers chose to apply an electrical circuit to function as a controller for providing feedback to learners. We here propose a draft of an electronic-based simulator of a newborn's intramuscular injection [Figure 8].

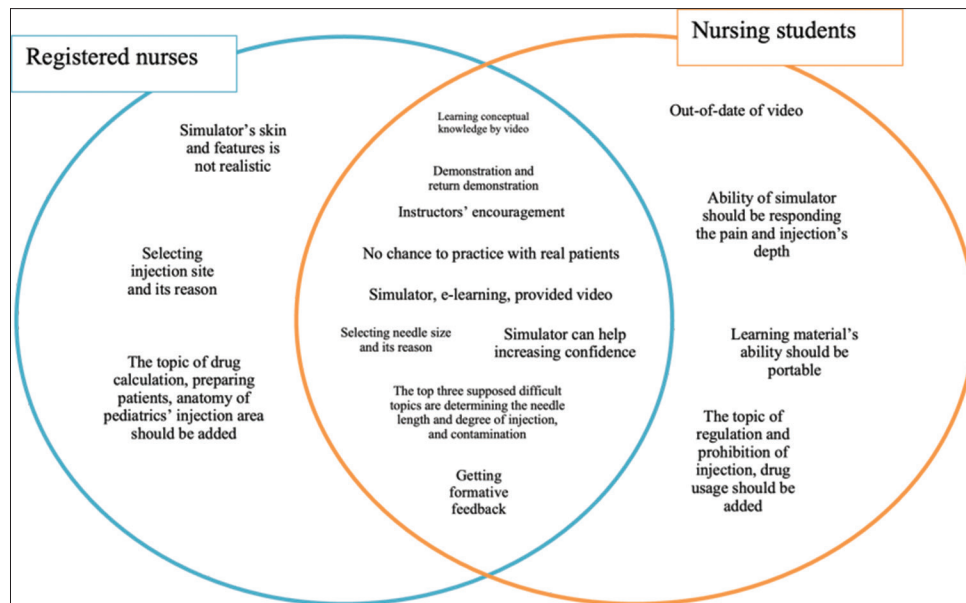


Figure 7: Registered nurses and nursing students' experiences and opinions in injection learning



Figure 8: A proposed electronic-based simulator of a newborn's intramuscular injection

## Discussion

The study aims to explore students' experiences in injection learning, registered nurses' experiences in injection learning, and the causes of problems in injection learning and to propose learning materials for solving such issues. The results showed that the demonstration and return demonstration with a simulator after learning the video were an appropriate learning approach for injection learning. The finding was concurrent with the results of studies conducted by Kamothi<sup>[20]</sup> that evaluated the effect of audiovisual aids on knowledge and skill in intramuscular injection. Its results indicated that the Planned Teaching Program, through demonstration and return demonstration with a simulator and audiovisual aids, can improve learners' knowledge and skill in intramuscular injection.

The finding of the study on the simulator as a learning material for pediatric injection learning showed that the learners need its function, including portability and providing feedback during learning. This aligns with the results of studies conducted by Cabrera-Muffly *et al.*,<sup>[28]</sup> who developed a low-cost transcervical laryngeal injection model for medical students, and Saxon *et al.*,<sup>[31]</sup> who developed a low-fidelity model for needle decompression procedure skill. Both suggested that the model should provide feedback to learners to improve their skills. Additionally, the result aligns with the study conducted by Ainsworth *et al.*,<sup>[29]</sup> who developed a simulator model for transcervical laryngeal injection and agreed that it was useful for providing visual confirmation of the correct needle placement and offered both tactile and audio feedbacks to learners to validate their performance.

Based on these findings, due to the shortage of nursing educators, patients' rights, and disaster preparedness, the proposed learning approach and material should be developed to be more effective for learners to learn equally and fairly, as in the previous study conducted by Nejadshafiee *et al.*,<sup>[33]</sup> which developed telenursing care for victims: a simulated study for introducing possible nursing interventions in disasters.

## Limitations and recommendation

This current study collected data from only one tertiary hospital and one nursing school in Bangkok, Thailand. Therefore, a larger sample size, including nursing students, registered nurses, healthcare students, and healthcare providers, should be studied to examine different results.



## Conclusion

The researcher's proposal aims to explore (1) students' experiences in injection learning, (2) registered nurses' experiences in injection learning, and (3) the causes of problems in injection learning and (4) to propose learning materials for solving such issues. We conducted a survey to describe these aspects, and the results indicated the following findings: inadequate availability of realistic simulators for students, the need to address specific content in coursework, and a requirement for greater attention to certain challenging issues.

This survey reveals that the fraction of intramuscular injections is less than the actual situations that the learners do. The traditional learning before actual injection to patients in clinical wards involves instructors' demonstration by using a sponge and a statistic simulator. The nursing students then return, demonstrate, and get the instructors' feedback. However, there are inadequate psychomotor's learning materials. The school lacks simulators that simulate the real texture of the patient's skin. Also, the contents of coursework should be updated, such as aspiration, the reason for practicing, the regulation and prohibition of the injection, the anatomy of an injection site, and drug usage, especially allergy and side effects. Moreover, we identified many issues involving the site for injection, determining the needle length and injection angle, and contamination.

Future studies are needed to complete the remaining two phrases of the design thinking, "developing a prototyping" and "conducting a prototype testing." We proposed a hands-on innovation for enhancing pediatrics' injection learning skills based on the learners' problems and needs, especially the sense of the correcting site and depth of injection.

Moreover, based on the findings, there are some interesting issues that should be surveyed regarding the learners' needs and problems that nursing students might not have enough opportunities to practice but will encounter as registered nurses, such as intravenous injection and intradermal injection. Therefore, the design thinking framework is necessary to focus on learners in any learning topic before developing innovations to aid their learning. This is because innovations should be based on their real-life problems or needs.

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## Conflicts of interest

There are no conflicts of interest.

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