Pharmacy Education (2025) 25(1) 493 - 501
https://doi.org/10.46542/pe.2025.251.493501

RESEARCH ARTICLE

Design of an educational escape game in a laboratory environment: A novel method to practise drug compounding competence for a hospital pharmacy

Tarja Toropainen[1], Ville Tahvanainen[2,3], Krista Laine[1]

[1] School of Pharmacy, University of Eastern Finland, Kuopio, Finland
[2] School of Applied Educational Science and Teacher Education, University of Eastern Finland, Joensuu, Finland
[3] Competence Development Unit, Siun Sote, North Karelia Welfare Area, Joensuu, Finland

Keywords
Drug compounding
Gamification
Hospital pharmacy
Pharmaceutical education
Teaching method
Working life

Correspondence
Tarja Toropainen
School of Pharmacy
University of Eastern Finland
Kuopio
Finland
tarja.toropainen@uef.fi

Abstract

Introduction: Escape games have recently been implemented in academic teaching. The aim of the present study was to design an educational escape game in a teaching laboratory themed to a hospital pharmacy. **Methods:** A four-member game design team was appointed. Concrete learning objectives were set as the basis for the game. Physical changes to the teaching laboratory facilities (e.g. equipment, audiovisual technology) were made during the drafting of the game manuscript. The game completion phase consisted of four pilot and three validation games, respectively. The game details were finalised based on the game supervisors' observations during the games and the reflective discussions. **Results:** The game was set in a linear form, and all the clue-related locks were based on five learning objectives. To complete the game, the required quality assurance and drug compounding procedures had to be accomplished within an hour. The supervisors monitored the game via video and audio connections and provided hints when necessary. A reflective discussion took place at the end. **Conclusion:** A real working-life situation in a hospital pharmacy was converted into an educational escape game for pharmacy students. The FARscape game has been used in both academic and professional training, suggesting the potential of gamification in education.

Introduction

Drug compounding competence continues to be an essential skill for pharmacy professionals worldwide (Kosari *et al.,* 2020; van der Schors *et al.,* 2021; Hussain *et al.,* 2023). For example, within the European Union, the Directive of the European Parliament and of the Council on the recognition of professional qualifications (2005/36/EC) states in Article 45 that every pharmacist must be competent in the preparation of the pharmaceutical form of medicinal products, together with the manufacture and testing of medicinal products. In the case of unlicensed preparations, both the prescribing practitioner and compounding pharmacist are responsible for medication and medicine safety within their areas of expertise (United States Pharmacopeia <795>, 2023; United States Pharmacopeia <797>, 2023; The Australian Health Practitioner Regulation Agency (AHPRA), 2024; European Pharmacopoeia 11.7., 2025). This requires specific training and competence, together with the co-operation between the compounding pharmacist and the prescribing physician for the best interest of the patient (Allen & Triplett, 2019; The Australian Health Practitioner Regulation Agency (AHPRA), 2024). It is therefore essential to equip pharmacy students with adequate compounding skills as part of their academic education.

Global teaching megatrends have adopted gamification as one of the potential ways to engage learners

(Paniagua & Istance, 2018), and escape games have been reported as effective pedagogical interventions (Kakos *et al.,* 2024). In academic education, escape games are considered suitable as a teaching method to support the aims of curricula (Tahvanainen *et al.,* 2021). It has been noted that games provide an effective way to combine transdisciplinary content into a coherent teaching intervention. Additionally, escape games have been utilised to support various assessment types, such as self- and peer-evaluation skills (Makri *et al.,* 2021; Palasik *et al.,* 2022). When integrated with traditional teaching methods, they can enhance the development of students' knowledge, as well as their generic, clinical, and didactic skills (Sauze *et al.,* 2024; Köse & Özcan, 2025).

In healthcare and pharmacy education, game-based methods have been adopted in many disciplines and contexts (Abdul Rahim *et al.,* 2022; Kanaan *et al.,* 2023; Quek *et al.,* 2024). In addition to students, continuous learning for pharmacy experts has recently been supported through the use of escape games (Berthod *et al.,* 2020; Cole & Ruble, 2021). Educational escape games have provided a novel and effective way of teaching pharmaceutical content (Hintze *et al.*, 2023). Pharmaceutical escape games have been implemented in both virtual and physical learning environments, such as classrooms or various escape game room settings (Hope *et al.,* 2023). For example, to enhance students' diabetes management skills, Palasik and colleagues (2022) set a game in simulated hospital facilities, while Eukel and colleagues (2017) used home-like conditions as the game environment. So far, only a few escape game applications have been set up in teaching laboratory environments (Vergne *et al.*, 2019; Kwok & Childers, 2023). In dealing with drug compounding, Caldas and colleagues (2019) created an escape game for nonsterile compounding in modified classroom conditions to evaluate pharmacy students' perceptions and content knowledge. Meanwhile, Berthod and colleagues (2020) designed an escape room game based on Good Manufacturing Practice (GMP) for hospital pharmacy professionals in a fictive cleanroom. It has been reported that authentic escape game learning environments can boost the learning process through an immersive atmosphere and layout (Pagano, 2013; Veldkamp *et al.*, 2022). However, to date, no educational escape game integrating drug compounding content into a laboratory environment has been published in the field of academic pharmaceutical education.

The present study aimed to design and create a pedagogical escape game in an authentic compounding laboratory environment. The main characters for the game design were pharmaceutical expertise in drug compounding, as well as generic skills such as work-life relevance, support group and collaboration skills, problem-solving skills and working under time pressure. Other aims of the process were gamification and further developing the teaching culture in pharmacy education. A competence-based approach and working life relevance were the cornerstones of the present design process. In this article, we present an example of a pedagogical escape game development project to share good practices for academic pharmacy education.

Methods

Game design team

A participatory and student-centred approach was applied to game design. Four team members were selected to plan and design the FARscape game. Two of them were university lecturers (Ph.D. Pharm) with expertise in drug compounding and analytics. They were responsible for the pedagogical and competence-based approach of the entire process. Two members were master students of pharmacy who worked as licensed pharmacists (B.Sc. Pharm) in hospital pharmacies before their graduation. Their role was to contribute both practical work experience and the student perspective to the process.

Room and game design

The design process for the FARscape educational escape game is shown in Figure 1. To begin, the target student group and the concrete learning objectives were set and documented for the game. The storyline and practical clues, which were designed to support the learning objectives, were designed afterwards. The Sm4rtLOC learning observation classroom (Tahvanainen *et al*., 2021) at the University of Eastern Finland and a private commercial escape game were benchmarked to gain a variety of ideas and to improve team members' knowledge of escape game perspectives and experiences. The various elements of the game, such as the clues, locks, correct answers and codes, were documented in the game manuscript in a linear format. This manuscript, supplemented with supporting material (*e.g.* model calculations), was used as a supervisor's manual during the game.

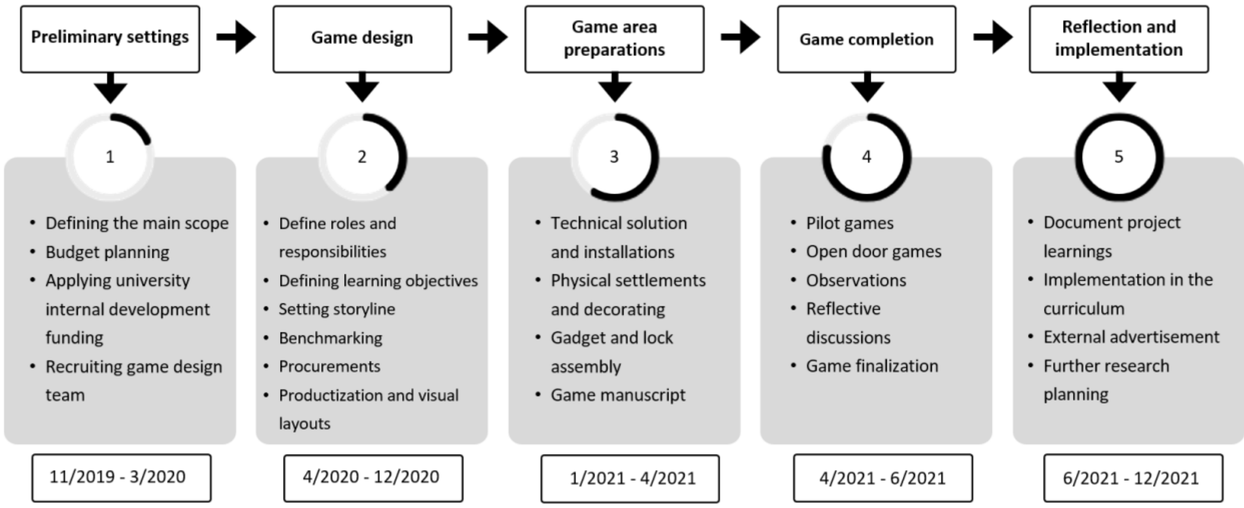

Figure 1: FARscape game design process

A dedicated room from a teaching laboratory was selected and furnished, with minor changes, as the game environment. The room had normally been used as an aseptic teaching laboratory with laminar flow hoods and basic laboratory equipment, while the recessed area leading to the room had been intended for preparatory work. The purpose of the temporary transformation was to increase the game's authenticity and the students' immersion. All the necessary accessories, such as locks, lighting and decorations, were purchased from hardware stores, grocery stores and online shops. The audiovisual equipment, i.e., the display monitor, microphone, camera and speakers, was installed by the university's technical experts. Initially, a wireless connection was installed from the supervision area to the game area. Due to the occasional unreliability of the setup, the wireless connection was later replaced by a wired connection.

Finalising the game

The game completion phase included the piloting and validation phases. Participation in the pilot and validation groups was voluntary and based on either a personal invitation (pilot players) or an open invitation (validation players). Game supervisors made observations during the games and reflective discussions to further improve the game experience. No separate data was collected from the players for research purposes. All players were informed about the audiovisual streaming related to the game, and oral consent was required before participation. Additionally, three written notices in the game area reminded players about the ongoing audio and video streaming. Participants in the pilot group were informed that no audiovisual equipment was used to record their gameplay performance. The validation group players gave written consent for the audiovisual recording of their game. However, the recorded data was not used for any research purposes. The players had the opportunity to leave the game area at any time during the game.

The first versions of the game were piloted from April to June 2021 with four voluntary groups (Table I). Immediately after each pilot game, the group members participated in a reflective discussion with the game supervisors. The participants were encouraged to share their experiences and suggestions to improve the game. The game details were finalised based on these discussions, together with the game supervisors' observations and notes. Following the pilot phase, the final form of the escape game was validated in August 2021 by observing three voluntary student groups (n =9). A validation phase was necessary to ensure inclusion of the perspectives of the final users and, in general, to observe the functionality of the game's storyline and clues.

Table I: Composition of game groups and members' competences during piloting and validation phases

Phase of design	Group number	Number of participants	Academic degree	Key competences
Piloting	1	4	Ph.D. (Pharm.), M.Sc. (Phil.), M.Sc. (Pharm.), B.Sc. (Pharm.)	Pedagogical, pharmaceutical, educational escape games, student perspective
Piloting	2	4	Ph.D. (Pharm.), Ph.D. (Phys. Chem.), Ph.D. (Chem.), M.Sc. (Pharm.)	Pedagogical, pharmaceutical, compounding, quality, chemistry and analytics
Piloting	3	3	Ph.D. (Pharm.), Ph. Lic. (Pharm.), M.Sc. (Pharm.)	Compounding, hospital and ward pharmacy, working life perspective
Piloting	4	3	Ph.D. (Pharm.), Ph.Lic.(Pharm.), MSc. (Pharm.)	Hospital and ward pharmacy, working life perspective
Validation	1	3	Students of pharmacy	Student and final user perspective
Validation	2	3	Students of pharmacy	Student and final user perspective
Validation	3	3	Students of pharmacy	Student and final user perspective
Total	**7 groups**	**23 participants**		

Ethics approval and informed consent

This project adhered to good scientific practice and the Finnish guidelines for research ethics.

Results

Through the FARscape design project, a real working-life situation in a hospital pharmacy was successfully converted into an educational escape game. The final version of the FARscape game was targeted at third-year pharmacy students before their final internship and graduation (B.Sc. Pharm.). Based on their previous studies and the curriculum's competencies, the following five learning objectives were set for the game:

After the game, the student should be able to

- plan and compound a medicinal product ordered from a hospital pharmacy on time
- complete the calculations related to compounding
- ensure the quality of the medicinal product before delivery
- apply the official regulations and key literature to compounding
- act as part of a group, facilitating group work with students' activity and competence.

These learning objectives were set as the core structure for the game design. They provided a basis for the various tasks to be solved (Table II). The storyline and each task were planned according to the real working-life compounding process. Each lock or clue corresponded to the learning objectives of the game. For the development of the game, we received a development grant of 7000 euros from the university administration, which was used to purchase materials and cover teachers' work hours.

Before the escape game, the supervisors briefly introduced the group to the concept of pedagogical escape games, provided necessary details (such as how to open different types of locks) and supported the group towards a safe studying atmosphere. After this 15-minute introduction, the group were given their first clue, which included their role during the game. The role of the supervisors was to support and facilitate students' performance and ensure the progression of the game. They intervened in the game only when necessary. The groups were not given direct instructions but rather hints, based on which they could proceed independently.

To start, the players were assigned the role of hospital pharmacists. Their primary goal was to respond promptly to an urgent order for a sterile wound care solution and deliver it to the hospital ward on time. The group was expected to adhere to quality assurance procedures, as well as the compounding protocol and batch documentation, throughout the game. The players were also expected to act professionally and follow critical compounding and quality control steps to ensure the medicinal product was released on time. All players completed the game without leaving the game area before it finished.

Table II: Linear progression and tasks of the FARscape game related to the learning objectives

Game room	Task (key tip)	Lock	Learning objectives ‡
Airlock	GMP cleanroom classes in the correct order (letter cards)	Directional combination padlock	4,5
Airlock	Hand hygiene and control (UV light)	5-digit number lock	4,5
Airlock	Gowning to the cleanroom (photo cards)	4-digit key lock box	4,5
Cleanroom	Documentation and quarantine procedures (quality assurance batch document)	3-digit number lock	3,4,5
Cleanroom	LASA medicines (quarantine cabinet)	Key lock	3,5
Cleanroom	Quality control of a substance (European Pharmacopoeia and quality assurance batch document)	4-digit number lock	3,4,5
Cleanroom	Compounding calculations (batch document)	3-digit number lock	1,2,5
Cleanroom	Compounding glassware selection (storage cabinet, batch document)	4-digit number lock	1,3,5
Cleanroom	Packing material selection (storage cabinet, batch document)	5-digit number lock	1,2,3,4,5
Cleanroom	Batch release (batch document)	Key lock	1,3,4,5
Exit	End of the game (FARscape diploma)	-	-

‡ Learning objectives:
1. Plan and compound a medicinal product ordered from a hospital pharmacy on time.
2. Complete the calculations related to compounding.
3. Ensure the quality of the medicinal product before delivery.
4. Apply the official regulations and key literature to compounding.
5. Act as part of a group, facilitating group work with the player's activity and competence

Based on the supervisors' observations during the game completion phase, several adjustments were made to the game design and the game area to improve the game experience (Table III). These changes were related to the lighting of the game room, the clues and the game time, which was set to one hour. All changes were implemented immediately after each game, and their effectiveness was evaluated by supervisors during subsequent games. To facilitate the supervision of the game, a few additions were made to the supervisors' manual to enable the provision of specific real-time hints to the players when necessary.

Table III: Supervisors' observations that led to changes in the game during the completion phase.

Topic	Observations	Change to the game
Lightning of the game room	Due to the low light levels, some players had difficulties reading text from the documents and literature.	An extra desk lamp was added above the table.
Clues	The players forgot the information about their clothing at the "*airlock*" as it was given before entering the game area.	A framed photograph was added to the "*airlock*" to mimic the image of the players reflected in the mirror.
	The players were able to use the UV lamp and get the code for the next lock before completing the current task.	The batteries of the UV lamp were removed and inserted into the locked box containing the task to be completed.
	Some players were confused about the old version of the pharmacopoeia available in the game room.	The pharmacopoeia's version number was manually updated by adding stickers to the book covers.
Supervisors' manual	There were numerous different ways to solve the required calculations.	The supervisors' model answer was updated in the manual to include all possible options for solving the calculation.
	It was difficult to identify the reason for the incorrect answer to the calculation based on the result alone.	The results of the intermediate steps in the calculations (e.g. calculated molecular weights of the compounds based on different sources of information) were added to the manual.
	It was difficult to identify the specific reason for any incorrect number in the incorrect lock code.	The correct sources for the lock code (e.g. batch numbers, colour codes, glassware numbers) and their correct order in the lock code were added in the manual.
Game time	Completing the game required more time than estimated for group discussion and decision-making between and during the tasks.	The game time limit was increased from 45 minutes to 60 minutes.

The current Good Manufacturing Practice (GMP) guidelines (European Commission, 2024) were adapted to both the contents and the floor plan of the FARscape game (Figure 2). The recess area was decorated as an "*airlock*", which was separated from the "*cleanroom*" by a locked door. Entrance to the game area was via a temporary space divider, behind which the supervisors could monitor the players at the very beginning of the game (tasks 1-3). During the later stage of the game (tasks 4-10), the players' activities were monitored via two cameras: a "*general view*" camera was set to cover the entire room, while the group work on the table was monitored through an overhead camera. There was a continuous voice connection from the room to the supervision area. If necessary, the supervisors could give spoken instructions via a separate microphone or write hints on the wall monitor showing the remaining time. Colour-changing lights and free-to-use mysterious background music were selected to create an impression of an escape room.

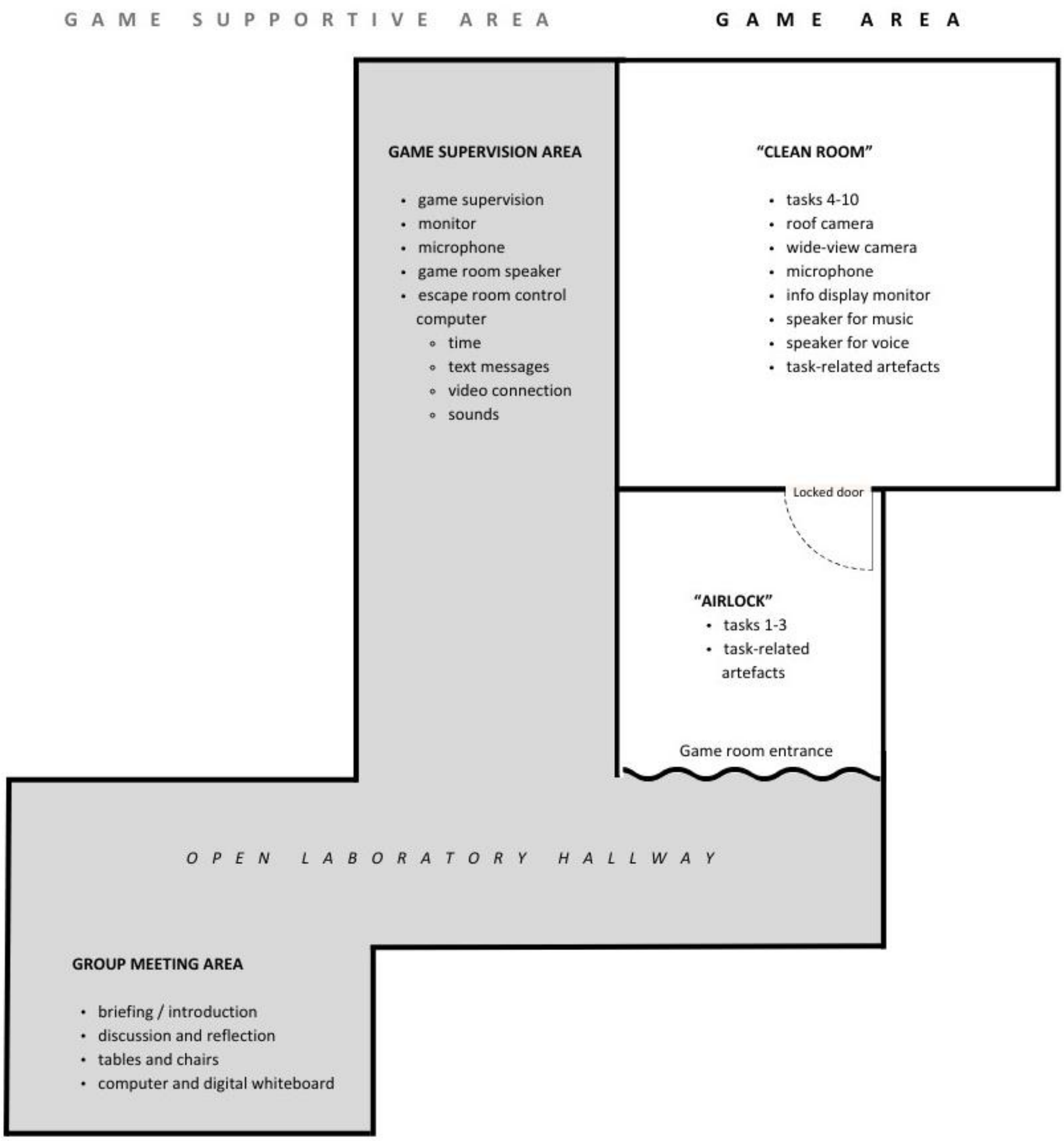

Figure 2: The floor plan of the FARscape game area and the game supportive area

After completing the game, the group participated in a reflective discussion (debriefing) with the game supervisors. To facilitate the discussion, the supervisors used open-ended questions, such as "*how did you find the game experience*", "*what did you learn during the game*", "*was there anything unclear*", "*how did you contribute to the group*" and "*what kind of feedback would you give to your fellow group members*". Based on the game performance, the supervisors pointed out their main observations relating to the learning objectives. The approximate duration of the reflective discussion was 15 minutes.

The game has been established as part of an optional course, "*Preparation of Dosage Forms in Hospital Pharmacies*" (4 ECTS). The course belongs to the pharmacy curricula in the School of Pharmacy at the University of Eastern Finland. It is intended for third-year pharmacy students and above. On average, 38 students participate in the course annually

Discussion

As the FARscape game design was set to serve both academic studies and the needs of working life, it was considered vital to have the management's acceptance for this teaching method at the early stage of planning. In addition to the content knowledge, the design team's teacher members needed to have responsibilities in both teaching and curriculum duties to ensure permanent teaching practice. Since the resources used for the FARscape game design were intended to be utilised as far into the future as possible, the game was designed to be durable over time. If necessary, individual clues in the game can be modified and updated, for example, if regulations change. The storyline and concept are also adaptable to meet potentially updated learning objectives. Changing the tasks or storyline of the escape game requires more work, but is nevertheless feasible.

In educational escape games, the limited playing time demands much mental effort of the players in terms of auditory, visual and cognitive loads. In our game, the purposeful playing time was set to follow the ideology of cognitive load theory (CLT); to avoid overloading the players' mental capacity in problem-solving situations (Sweller, 1988; van Merrienboer *et al.,* 2003; Kalyuga *et al.,* 2010). The overload of cognitive stimulus was prevented by: 1) supporting the game player with hints, 2) phasing the game into steps, 3) setting various levels of difficulty within the tasks, and 4) ensuring the players had adequate content knowledge in advance. These were crucial elements in supporting the players' resilient learning without frustrating them.

A reflective discussion (debriefing) is recognised as a vital part of an educational escape game experience to promote and ensure students' learning (Friedrich *et al*., 2019; Sanchez & Plumettaz-Sieber, 2019; Veldkamp *et al*., 2020). In our game, this discussion allowed players to ask about and confirm any issues they felt unsure about. The players were encouraged to give feedback to their fellow players and to reflect on their input to the game. It was found that the players could group quickly, even if they were previously unknown to each other, and that no prior experience of escape games was needed for the students' success in the game.

Based on our experience, the educational escape game design process is highly engaging and can be implemented in a curriculum at relatively low cost. However, creating an escape room requires a considerable amount of time. One of the key challenges found was that only a limited number of players can participate in the physical game at one time. This makes the physical game format time-consuming for the teachers, and therefore, the adaptation of the physical game requires careful consideration when implementing it in mass courses. For large student groups, it would be more beneficial to utilise a digital or virtual format for the game to allow for more cost-effective implementation. However, it must be noted that a virtual game format is a compromise, and this may detract from the skill-based and interactive content necessary for the full learning experience. Overall, selecting an educational escape game over other teaching methods requires careful consideration and a well-reasoned evaluation of which approach will yield the greatest benefit in each situation. Although educational escape games have been shown to be effective in enhancing short-term learning, evidence on their long-term impact compared to traditional teaching methods remains limited (Kakos *et al.,* 2024; Quek *et al.,* 2024; Köze & Özcan, 2025).

To ensure persistent teaching practice, the learning objectives of the game must be a genuine part of the curriculum. In our case, the lifecycle of the FARscape game was ensured by applying for funding and support from the University administration for its further development. It was realised that participation in the planning process, together with positive feedback during the teaching interventions, is key to maintaining a high usage rate for the game. The novelty of the teaching method has also attracted academic teaching staff to visit the FARscape game facilities to try the method by themselves in the future.

In summary, the FARscape game design was launched to support pharmacy students' learning process towards cumulative working life competence. The FARscape game has attracted interest even outside our degree programmes: so far, it has also been used in continuous training of community pharmacy compounding staff and as a collective activity for hospital pharmacists. While the present study aimed to describe the overall design process and functionalities of this escape game, it would be crucial to prove its pedagogical value from the students' perspective next.

Conclusion

The overall experience of both the design process and the method itself was positive. We suggest that gamification is a potential way to learn and teach generic skills together with compounding-related content. As a pedagogical method, the FARscape game created an attractive learning environment in a teaching laboratory. The final version of the game was included in the optional course dealing with compounding in hospital pharmacies as a part of the curriculum. The design process showed that this novel pedagogical method could be suitable for academic pharmacy teaching at an advanced level and that it can be implemented in a compounding laboratory environment. In the future, the FARscape learning environment will remain an attractive place to visit on the university campus. We have found that this learning environment can also promote continuous learning opportunities for in-service pharmaceutical professionals and allow them to reflect on their professional skills.

Acknowledgement

The authors would like to thank Mr. Juho Ronkainen (M.Sc. Pharm) and Ms. Laura Leppänen (M.Sc. Pharm) for providing a student- and work-life perspective for planning; Mr. Marko Antikainen for technical support, and the members of the pilot teams for their feedback to improve the game details. The authors would also like to appreciate the cooperation of the Kuopio University Hospital Pharmacy during the pilot phase, and the University of Eastern Finland for providing financial support for the process.

Conflict of interest

The authors declare no conflict of interest.

Source of funding

The authors received a grant from the University of Eastern Finland to apply escape room pedagogy to pharmacy education.

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