



**Escape to learn: the effectiveness of escape
rooms for engagement and learning outcomes of
undergraduate medical students.
A randomised controlled trial.**

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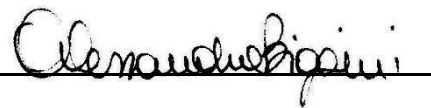
**A thesis submitted to the School of Postgraduate Studies, Faculty of Medicine
and
Health Sciences, Royal College of Surgeons in Ireland,
in fulfilment of the degree of Master of Science**

Supervisors: Professor N McCallion, Dr J Moffett

Candidate Thesis Declaration:

I declare that this thesis, which I submit to RCSI University of Medicine and Health Sciences for examination in consideration of the award of a higher degree <insert name of degree> is my own personal effort. Where any of the content presented is the result of input or data from a related collaborative research programme this is duly acknowledged in the text such that it is possible to ascertain how much of the work is my own. I have not already obtained a degree in RCSI or elsewhere on the basis of this work.

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To my Family

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LIST OF ABBREVIATIONS

AAR: After-Action Review

CNS: Central Nervous System

CVS: Cardiovascular

ENT: Ear Nose and Throat

ER: Escape Room

GER: Group Escape Room Teaching

GRT: Group Routine Teaching

GI: Gastrointestinal

GM: Game Master

ILO: Intended Learning Outcomes

MCQ: Multiple Choice Questions

OSCE: Objective Structured Clinical Examination

OFC: Occipital Frontal Circumference

RCSI: Royal college of Surgeons in Ireland

RCT: Randomised Controlled Trial

SBE: Simulation-Based Education

SHO: Senior House Officers

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SUMMARY

Escape rooms (ERs) are gaining popularity as innovative educational tool in health professions training. By presenting participants with a series of sequential challenges, ERs compel students to solve progressively complex problems, requiring collaboration and sharing of expertise, knowledge, and skills, and mimicking the teamwork and problem-solving abilities required in clinical practice.

In this study, I designed an educational ER centred on neonatal care, where teams of medical students need to solve content-specific challenges to progress through the activity. These challenges simulated leadership and management hurdles commonly encountered in professional practice, while reinforcing academic knowledge covered in traditional teaching sessions.

The primary aim of this research was to evaluate the effectiveness of ERs as educational tools for fourth-year medical students enrolled in a Paediatric course, specifically during their Neonatal rotation at the Rotunda Hospital.

A randomised controlled trial (RCT) design was employed, comparing students' performance on Objective Structured Clinical Examinations (OSCEs) and Multiple-Choice Questions (MCQs) between those who participated in the ER and a control group. Additionally, a post-activity survey, based on a five-point Likert scale, was administered to gather feedback on students' learning experiences.

Although no significant differences were observed between the students that participated in the ER and the control groups in terms of OSCE and MCQ scores, survey responses revealed that the majority of students found the ER to be a valuable learning tool. Seventy-eight percent of participants indicated that they learned better in a game-based format and highlighted the benefits of teamwork and lateral thinking. Furthermore, all participants expressed a willingness to recommend the ER activity to their peers.

Overall, although the quantitative performance data did not reveal statistically significant improvements in exam scores, the qualitative feedback reveals the potential of ERs as an effective educational tool for enhancing student engagement and perceived learning. These findings suggest that while ERs may not directly lead to a measurable difference in standardised assessments, they foster active, team-based learning, and enhance

engagement, teamwork, critical thinking, and practical application of neonatal knowledge among medical students. This highlights the potential role of educational ERs in promoting soft skills training within healthcare education, warranting further exploration into their long-term educational benefits.

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ACCOMPLISHMENTS

Presentations & Outreach

Irish Network of Medical Educators

January 2024

Escape room as pedagogical tool in Neonatology. Preliminary results of medical students' learning experience after participating in an educational escape room.

8-minute Researcher Presentation

Irish Network of Medical Educators

January 2024

Designing an escape room as educational tool for medical students. Considerations as designer and game master of a medical escape room.

3-minute Flash Presentation

1. INTRODUCTION

1.1 Chapter Overview

This chapter provides background and context for the work described in this thesis, including an overview of the key literature that informed this research. It comprises an introduction to the concept of escape rooms (ERs), explaining what they are and how they function, followed by a summary of the use to-date of ERs as an innovative educational tool, specifically within the context of teaching and learning.

The application of ERs in education is explored, supported by relevant educational concepts and theories. These include active learning, constructivism, Gagne's Conditions of Learning, Miller's Pyramid, Bloom's Taxonomy, Kolb's Experiential Learning Theory, and situated learning, each of which offers valuable insights into how ERs could enhance learning experiences.

Building on this theoretical foundation, the chapter examines the role of ERs in assessment, highlighting their potential to assess a wide range of skills and knowledge in an engaging and interactive manner. It also provides practical guidance on designing ERs for teaching and learning, emphasising the importance of aligning them with educational objectives.

Finally, the introduction explains the specific educational context of this research project, including the study context, institutional context, with a particular focus on the newborn clinical examination and core learning points of the curriculum. Finally, the chapter concludes with the overall aim and objectives of this research, explaining the gaps in current literature and how this research intends to address them.

1.2 The Escape Room: What Is It and How It Works

An ER is an immersive cooperative live-action game, in which teams of players achieve a specific goal in a limited amount of time through solving a crescendo of clues, puzzles, and a variety of tasks (Nicholson, 2015).

ERs are often used for entertainment purposes, with players working together to "escape" from a site or meet a set of pre-set objectives in an established amount of time to win the game (Makri, 2021; Taraldsen, 2020; School-break.eu 2020).

Typically, ERs impose a time constraint to complete the mission. Time limits and pressure add an adrenaline rush, enhancing the overall thrill of the experience and creating a sense of urgency and excitement that compels players to think quickly and work efficiently (Veldkamp, 2012).

In an ER all the activities are linked together and the solution to one puzzle or clue will lead to the next step: it may be the start of a puzzle, a code for a numeric lock, a crucial hint to solve a cipher and so on.

Each team usually consists of two to ten players who must combine their unique skills and perspectives to solve puzzles and clues. As in any cooperative game, ER team dynamics and alliance are vital, and the game is designed to be a collaborative experience, encouraging communication, teamwork, and the sharing of ideas.

To be successful, participants will need to continuously work together throughout the whole game, sharing information about what is found and helping each other.

Advancing through several challenges, participants will face new and progressively more complex problems that they must solve through mutual help and interaction with other teammates. These real-time experiences can be either physical, digital, or combined.

In an ER, the game master (GM) plays a pivotal role in ensuring a smooth flow of the game and providing an enjoyable experience for the players. They are an integral part of the game and are part of the organisation team.

A GM is “an officiant for regarding rules, an arbitrator, and a moderator for the game” (Rosenberg, 2005; Porter, 1988). As part of their role, GMs carefully follow the progress of the team, adjusting the pace and intensity of the game in response to the players' actions and reactions and ensuring that the immersivity remains unbroken. Their main role is to monitor the game and give guidance for the players, helping with hints and clues where players request assistance or appear to be stuck or frustrated. An effective GM makes sure that players feel engaged, supported, and satisfied with their experience. This may involve observing participants' dynamics, adapting hints to suit individual groups' needs, ensuring addressing accessibility and delivering an overall reproducible experience.

Should an unexpected issue arise during gameplay (e.g. a technical malfunction or misunderstandings) the GM will problem-solve swiftly and effectively without disrupting the flow of the game addressing any concerns or questions that arise during the game.

The GM is designated to discuss the experience with the players, answering any questions, explaining any puzzles or clues that they did not understand, and feeding back overall.

The GM also leads a debrief, as it is a crucial step of acquisition and retention of knowledge. In educational ERs, such debriefs are particularly important for facilitating learner reflection and supporting the transfer of learning from the game environment to the real world (Nicholson, 2012).

At the end of each session, it is the duty of the GM to reset the room, put all puzzles and clues back in their original places and ensure everything is ready for the next group of players.

1.3 Origins of the Escape Room

The first ER dates back to 2007, when Mr Takao Kato organised the first *Real Escape Game* in Kyoto, Japan (SCRAP, 2024). Kato's idea was to bring all the adventures from online point-and-click adventure games into real life, transitioning them into real-life experiences to let people experience first-hand what is portrayed in these online games. He turned bidimensional mysteries and challenges into real-life 360-dimensional experiences and, following his vision, invented the world's first live action game, called リアル脱出ゲーム in Japanese, or the *Real Escape Game*™.

The game quickly became popular and, despite its challenging level of difficulty (players had a 2% chance of completing the game), the event was constantly selling out. This game format quickly expanded across Asia, and, from the early 2010s, rapidly gained traction. ERs first reached Europe with the Hungarian company Parapark in 2011 (Hooker, 2024), before arriving in the US in San Francisco around 2012-13 (SCRAP, 2024). From the US, ERs spread like wildfire, becoming a worldwide cultural phenomenon that transformed the entertainment landscape.

1.4 The Escape Room as Educational Activity

Games have been used as a learning tool for centuries, and their role in education has become increasingly important in modern pedagogy. Game-based learning (Plass, 2015), including the use of ERs, is an active learning technique where games are employed to enhance student learning. It has been demonstrated to be a dynamic and effective educational strategy. The benefits of game-based learning encompass active learning, creativity, problem-solving, self-regulation, fun, and social interaction (Bober, 2010).

An educational ER/game can be defined as “an instructional method requiring learners to participate in collaborative playful activities explicitly designed for domain knowledge acquisition or skill development so that they can accomplish a specific goal (e.g., escape from a physical room or break into a box) by solving puzzles linked to unambiguous learning objectives in a limited amount of time” (Fotaris, 2022).

ERs for educational purposes started to emerge around 2010 (Gurpinar et al., 2010). Since then, ERs have been creatively adapted for a variety of educational purposes across a wide range of disciplines and settings, and the diversity of applications in education highlight their versatility and effectiveness as learning tools (Fotaris et al., 2019).

Educational ERs require students to apply their theoretical knowledge in practice, bridging the gap between classroom learning and clinical application.

The collaborative environment encourages communication among team members, promotes clarification of team member roles essential in real-life healthcare settings, and offers a team-based approach fostering a deeper understanding of how healthcare professionals must work together to provide optimal patient care (Fusco, 2021; Schmuhl, 2023).

This experience also mirrors the multidisciplinary reality of healthcare by requiring participants to work as a team to solve numerous challenges that simulate patients' care scenarios.

The acquisition of these key professional skills is a transferable expertise that aligns well with the long-term goals of clinical staff curricula (Rosenkrantz, 2019).

Also, ERs typically offer immediate feedback as students progress through challenges with a unidirectional answer. This allows them to reflect on their mistakes, adjust their clinical reasoning, and improve their approach to future problems.

A review of the current literature on educational ERs demonstrates the adoption of this novel approach to learning and assessment across a diversity of subjects and fields (Vörös, 2017; Cotner, 2018; Hermanns, 2017; Morrell, 2019; Friedrich, 2018; Kinio, 2018; Van der Linden, 2019; Vergne, 2019; Peleg, 2019). However, systematic review and analysis of the literature is complicated as there is wide heterogeneity in education goals of research, as well as in the methodology used to evaluate outcomes. This is, in part, due to the wide variation in room design that makes direct comparisons difficult (Taraldsen, 2020). Despite this, ERs provide promising opportunities in the field of health professions education (Guckian, 2020).

In particular, ERs have proven extremely useful in facilitating learning around teamwork and collaboration, motivating staff members, often from different backgrounds, to engage in a playful, collaborative effort based on sharing expertise, knowledge, and skills to create a positive outcome. This is a critical skill for the healthcare professional (Taraldsen, 2020; Gordon, 2019; Franco, 2019) where the coordination of wide-ranging multidisciplinary skills is essential to address the complexity of quality patient care.

1.5 Educational Concepts and Theories of Relevance in Supporting Learning through Escape Rooms

A number of important established educational concepts and theories are relevant to the use of ERs as a pedagogical tool in health professions education. Such pedagogical terms can be employed to better conceptualise how learning takes place within an educational environment.

1.5.1 Active learning

In recent years, ERs have evolved as a method for enhancing engagement, team-building, critical and lateral thinking, problem-solving and leadership (Fotaris, 2019). The use of ERs in education encourages students to learn actively. Participating in an educational ER engages students in teamwork (cooperation), builds practical experience on pre-existing knowledge (construction), and provides opportunities to practise skills and

apply prior learning in a playful manner (contextualisation) (Manzano-León, 2021) before applying them in real-life patient care situations.

Research has established that an active participation from the learners is more effective than passive learning modalities (Theberge, 1994; Freeman, 2014; Astin, 1999). This effectiveness involves not only the volume of knowledge processed, but also improves both time efficiency and long-term retention of material.

The act of active learning involves student construction, contextualisation, and cooperation of the learning material (Hazlett, 2009). In this sense, learning can be constructed if students can organise new information in a logical manner, and if their knowledge builds on content and skills that have been learned previously (Duffy, 1992). New subject matter is more easily contextualised when learners determine its relevance to their work or personal experiences (Mikkelsen, 2007), and it is defined as cooperative if it is approached by groups working together collaboratively (Johnson, 1998).

1.5.2 Constructivism

Learning through ERs also draws heavily on constructivist approaches. Constructivist theory suggests that learners actively construct and scaffold their knowledge and understanding of the world based on their experiences and interactions (Kalpana, 2014). This pedagogical approach contrasts with traditional instructional methods where the transmission of knowledge flows from teacher to student. Through the lens of constructivism, the learner has an active role in building their own understanding, highlighting the importance of personal experiences, social interaction, and reflection in the learning process (Richards, 2012). In educational ERs the student (player) constantly faces new, difficult problems, which can be solved through the interaction with his teammates with the support of the teacher (Velderkamp, 2020).

1.5.3 Gagne's Conditions of Learning

Gagne's Conditions of Learning proposes a hierarchical classification of learning types underpinned by a framework for designing instruction that aligns with specific learning objectives (Gagné, 1974). This framework is founded on integration between cognitive psychology principles and the design of instruction, providing a structured approach to

education based on five categories of learning outcomes, each requiring different conditions for learning:

- verbal information and knowledge that can be declared or stated (e.g. facts and data);
- intellectual skills (e.g. problem-solving or procedural knowledge abilities, like mathematics and logical reasoning);
- cognitive strategies (including thinking, and problem-solving, attitudes of learners);
- learners' predispositions towards the concepts and the information received; and
- motor skills involving physical abilities, and muscular movements.

In his framework, Gagné theorised nine instructional events, or steps, that correspond to and support the internal processes of learning, providing a comprehensive framework for effective instruction, and ensuring that learners are engaged, supported, and able to apply their new knowledge and skills successfully.

The educational psychologist considered capturing learners' attention to be the opening step to priming students for learning.

Next, clearly stating the learning objectives provides direction and purpose, motivating learners to engage with the content and helping them to understand what they are expected to achieve by the end of the lesson.

Stimulating recall of prior learning is the third step. This involves encouraging learners to retrieve relevant knowledge or skills they have previously acquired. By connecting new information to existing knowledge, they can better understand and retain the new material.

The fourth step is presenting the content i.e. new information is delivered in a clear and organised manner.

The fifth step is providing learning guidance offering instructional support to help learners grasp complex concepts and apply new skills effectively.

Eliciting performance is the sixth step. Here, learners are given opportunities to practise what they have learned through exercises, activities, or discussions. This active engagement reinforces learning and allows learners to apply their knowledge in practical contexts.

Providing feedback is the seventh step. Constructive feedback is essential for reinforcing correct performance and addressing any errors. Immediate and specific feedback helps learners understand what they did well and where they need improvement.

To follow, assessing performance is where learners' understanding and skills are evaluated through tests, quizzes, or performance tasks. This assessment helps determine whether the learning objectives have been met and identifies areas that may need further attention.

Finally, enhancing retention and transfer is the ninth step that involves helping learners solidify their understanding and apply their new knowledge to different contexts. Techniques such as discussing real-world applications and encouraging learners to reflect on their learning can enhance retention and facilitate the transfer of skills to new situations (Gagné, 1974).

By aligning the elements of an educational ER room with Gagné's taxonomy, educators can optimise learning, creating an experience that is not just fun but also effective in promoting desired learning outcomes.

- *Gaining attention of the learners*: novelty, uncertainty, and the surprise element of an educational ER can present a stimulus to capture students' attention and ensure they are "hooked"- interested and primed to engage with the activity.
- *Inform students of the objectives or outcomes*: the explicit learning outcomes of the activity are outlined at the beginning of the activity to further support learner motivation, as well as provide clarity.
- *Stimulate recall of prior learning*: quizzes and puzzles included in the ER are focused on relevant issues and prior learning. These elements can be used to reproduce the hurdles in real-world healthcare management and leadership, as well as "reawaken" learners past experiences.
- *Present the content*: an educational ER can be used to present and cue themes, topics and content.
- *Provide learning guidance*: learning guidance may be given throughout the educational ER in terms of introduction of varied learning strategies and scaffolding, with instructional support and facilitation by the GM as needed.

- *Eliciting performance*: ERs offer opportunities for students to practise and apply what they have learned. This reinforces their new skills and knowledge and confirms correct understanding of course concepts.
- *Provide feedback*: feedback is intrinsic to the progression through the various steps of the ER. Every unlocked lock is a confirmation of the student's knowledge, every progression through the game offers positive feedback on competency. At the end of the activity, a debrief session assesses and facilitates learning, allowing students to identify gaps in their understanding.
- *Assess performance, retention of information and transfer*: inbuilt curricular assessment points can formally assess whether the expected learning outcomes have been achieved on previously stated course objectives. (Note that the enhancement of retention and transfer of knowledge after use of an ER will be central to the hypothesis and main objective of this study).

1.5.4 Miller's Pyramid

Skills development is a fundamental part of health professions education, and the special nature of this process has been emphasised through the concept of Miller's theory (Miller, 1990).

According to Miller, clinical competence in medical education is assessed through a pyramidal framework, often referred to as Miller's pyramid (Figure 1). This framework is divided into four hierarchical domains, each representing a different level of competence.

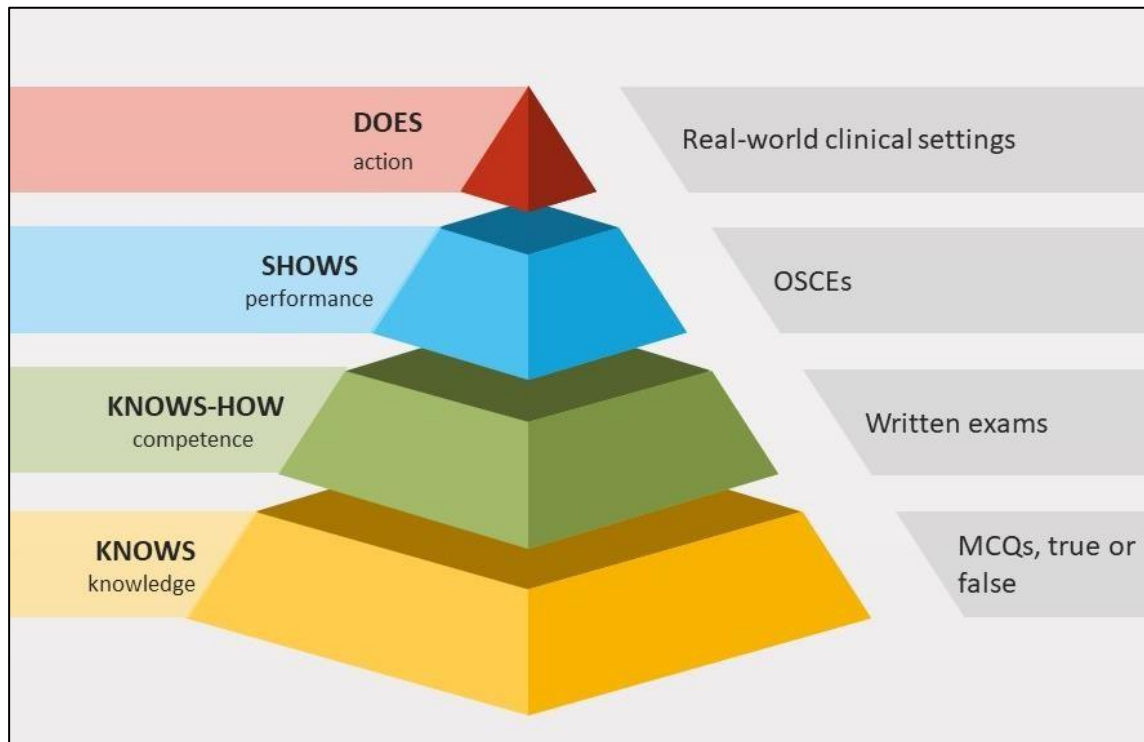


Figure 1: Miller's pyramid of assessment. Adapted from Miller (Miller, 1990)

Figure 1: Miller's Pyramid illustrates the hierarchy of clinical competence assessment, progressing from foundational knowledge ("Knows") to practical application and professional performance ("Does"). The four levels Knows, Knows How, Shows How, and Does represent a framework for evaluating a learner's progression from theoretical understanding to real-world execution in medical education.

At the base of Miller's pyramid there is "knows": the foundational level of competence. It represents the cognitive domain where medical students acquire the necessary factual knowledge and understanding that will support their medical profession. Knowledge assessment can be performed via multiple choice questions, extending matching questions, or True-False tests.

The next level is "knows how" i.e. the application of knowledge. At this stage, students must demonstrate that they can apply their knowledge in practical situations. This can be assessed through essays, case studies or problem-solving exercises that require students to explain how they would handle specific clinical scenarios.

The third step of Miller's framework is "shows" where students are called to demonstrate their skills in a controlled environment. This is typically assessed through objective structured clinical examinations (OSCEs), and simulations where students must perform tasks or procedures under observation.

The pinnacle of the pyramid is “does” and represents the highest level of competence, where students consistently perform in real-world clinical settings. This involves actual practice where learners apply their knowledge and skills to patient care in a clinical environment. This level is often assessed through direct observation of clinical performance, feedback from supervisors, and performance reviews.

Miller's Pyramid emphasises a progression from theoretical knowledge to practical application, ensuring that medical education not only imparts knowledge but also prepares students to effectively apply this knowledge in clinical practice.

Miller's Pyramid can be applied to educational ERs as follows:

- *Level 1, Knows*: the ER contains multiple basic facts, definitions, or formulae that are required to solve the puzzles.
- *Level 2, Knows how*: Participants are required to explain concepts to each other, interpreting information, or summarising key points, in order to progress through the game. For example, they may need to understand the relevant physiology to decipher a code.
- *Level 3, Shows how*: Students are asked to use their skills to solve problems and make decisions in new situations.
- *Level 4, Does*: the performance in practice is the aim of any educational tool and, with this study, I intend to demonstrate that an educational ER is a valid way to enhance students' skills and performances.

1.5.5 Bloom's Taxonomy

Bloom's Taxonomy is a framework used in education to classify learning objectives into different levels of complexity and specificity (Figure 1.2). Educational ERs can engage learners across all six levels of Bloom's Taxonomy providing a framework for designing learning objectives, assessments, and activities that target different levels of cognitive complexity (Menon, 2019).

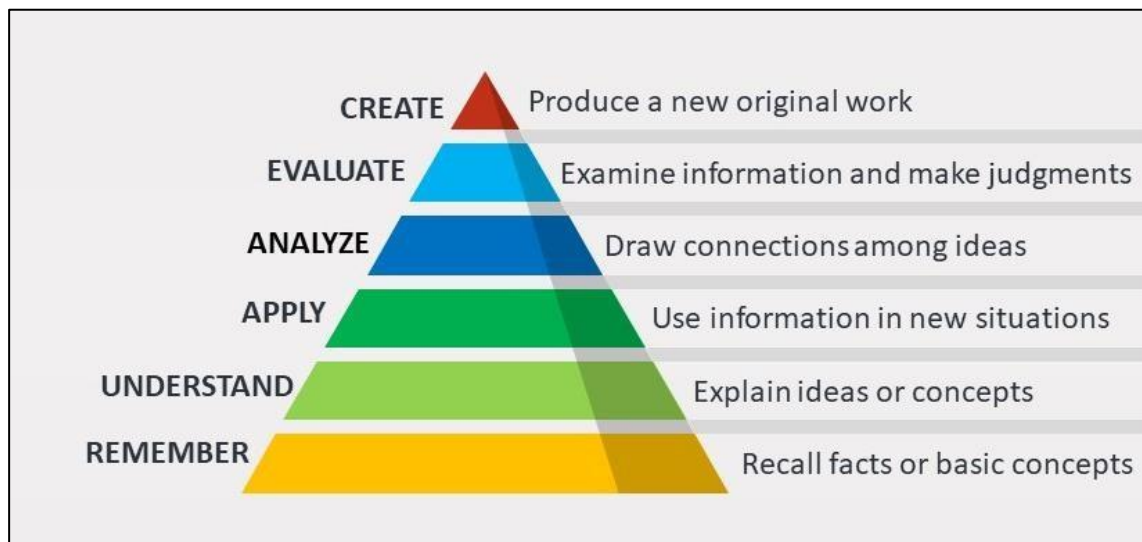


Figure 1.2. Six levels of Bloom's taxonomy. Adapted from Bloom (Bloom, 1956).

Figure 1.2. Bloom's Taxonomy outlines the hierarchical stages of cognitive skills in learning, ranging from basic knowledge acquisition to complex evaluation and creation. The six level include Remember, Understand, Apply, Analyse, Evaluate, and Create, and provide a structured framework for educators to design learning objectives and assess student progress across increasing levels of cognitive complexity.

Bloom's classification is pictured as a pyramid which depicts lower order cognitive processes, such as remembering, at the base, i.e. recalling or recognising facts, information, or concepts. Educational ERs align well with this and can be designed to include puzzles that require students to recall factual information.

Understanding is the next level of the pyramid. Here, the student can explain ideas and notions, engaging in learning tasks such as summarising, paraphrasing, or explaining concepts. For example, tasks highlighting understanding may be used in puzzles or riddles to be solved to progress through the game.

At the next level of Bloom's Taxonomy are higher order cognitive processes such as applying. Here, learners use information in new situations, and apply principles to solve problems in different scenarios, such as using a medical formula to decode a message.

Analysing is the next level, where the information is broken into its components in order to understand patterns and underlying organisational structures. At this level, learners develop tasks that require breaking down information into parts and examining relationships. In an educational ER, this level could translate, for example, to the need to analyse a scenario to find hidden connections or patterns that lead to the next clue.

At the top of the pyramid are evaluating and creating. Evaluating involves assessing the validity of arguments and making critiques based on criteria and standards, while creating, the highest in Bloom's hierarchy, involves synthesising information to generate new ideas, and ways of thinking. This is the core of any educational ER, and it is where students are brought through the game to evaluate different solutions to a problem and choose the best one to proceed and start developing new hypotheses based on provided clues and information. (Adams, 2015; Bloom, 1956).

1.5.6 Kolb's Experiential Learning Theory

A further educational theory of interest to ERs is experiential learning theory. This educational framework, proposed by Kolb (Kolb, 1984), is based on the assumption that learning is a process whereby knowledge is created through the transformation of experience (Figure 1.3). For Kolb, allowing students to apply knowledge in real life situations promotes engagement, thinking, creativity, problem solving, collaboration, and communication skills. Students can achieve their best learning outcomes following a cycle of experiencing, reflecting, thinking, and acting and thus, in progressing through this four-stage model, they gain knowledge and skills.

Kolb's Experiential Learning Theory emphasises the importance of experience in the learning process, highlighting four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Designing an educational ER aligned with Kolb's taxonomy involves incorporating elements that engage learners in each of these stages.

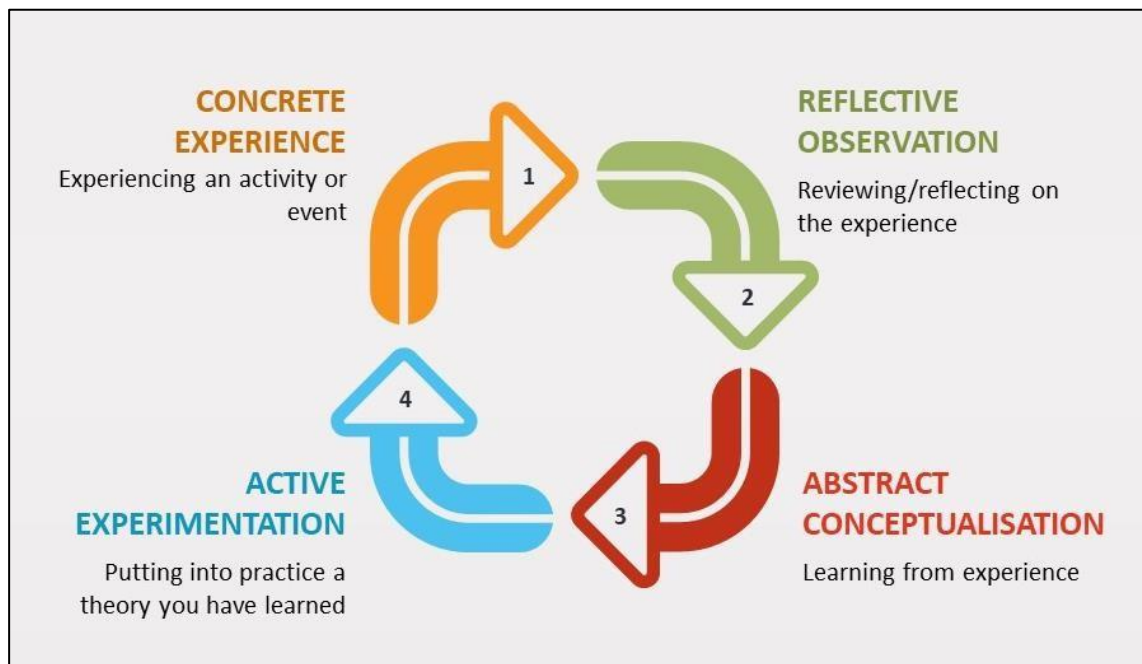


Figure 1.3. Kolb's experiential learning theory cycle.

Adapted from Kolb (Kolb, 1984)

Figure 1.3. Kolb's Experiential Learning Cycle represents a continuous process of learning through experience, consisting of four stages: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. This model emphasizes the importance of reflection in transforming experiences into knowledge, guiding learners through a cycle of action, reflection, and application to enhance their learning.

A concrete experience is the initial stage where the learner actively experiences an activity or event, and it implicates a direct involvement in a specific situation. The immersive environment of the ER provides the potential for hands-on activities and realistic scenarios that allow learners to actively engage with the material. After the experience, the learner will have a phase of reflective observation where they reflect on what happened, considering what was successful or challenging and considering different perspectives. A debrief at the end of the escape game is a vital component, prompting students to reflect on their actions, what worked and what did not. The next stage is abstract conceptualisation, where the student starts to form theories, concepts or action plans based on their reflections. Through the game, they develop an understanding of the underlying principles or patterns observed during the experience. In the last stage of the cycle, the active experimentation, students apply what they have learned to new situations, testing out their theories and concepts in practice, leading to new experiences, and thus continuing the cycle (Kolb, 1984).

Educational ERs can be mapped to Kolb's experiential learning cycle, as they allow active experimentation in a safe environment (Poore, 2014). The core of the ER experience itself is the concrete experience where participants are involved in solving puzzles, finding clues, and completing tasks within a set time limit (Guckian, 2020).

This hands-on engagement immerses them in the learning process and creates a comprehensive and dynamic learning experience.

Aligning the educational ER with experiential learning theory ensures that students not only engage with the material in a fun and interactive way but also reflect on their learning, understand the underlying concepts, and are empowered to apply their knowledge in new contexts. This approach fosters a deeper understanding and encourages continuous improvement in both learning and problem-solving skills (Fotaris, 2022).

1.5.7 Situated learning

Situated learning is a theory of education that posits that learning occurs most effectively within a context that is meaningful and relevant to the learners (Bloch, 1994). This approach connects learning with real-world contexts and social practices by engaging learners in authentic activities and fostering social collaboration.

In this pedagogical strategy, learning occurs through social interactions and the integration of prior knowledge with authentic, informal, and often unintentional contexts: students transition from novices to experts by becoming more active and engaged within their social community, where learning is frequently incidental rather than intentional.

The major elements of situated learning are context, content, community and participation.

With respect to the context, narrative plays a vital role in the transfer of information, and learning environments should be as close as possible to the environments in which the skills or knowledge will be used, reflecting the real-world situations in which the knowledge will be applied.

The focus in this educational framework is not on content retention. Instead, it emphasises reflective and higher-order thinking, applying results to solve real-life

problems providing a model for achieving an integration between a fast and immediate experiential thinking and the depth of reflective practice.

Learners engage in collaborative activities where they can share ideas, provide mutual support, and learn from each other. This community of practice allows learners to participate in shared activities and practices.

Participation refers to the dynamic process whereby learners engage in the exchange of ideas, problem-solving, and active involvement within a social context. In this framework, learning is viewed not just as the acquisition of knowledge but as participation in social and cultural practices.

Educational ERs are well-aligned with the theory of situated learning, and they foster authentic learning experiences and enhance the practical application of skills and knowledge by immersing students in scenario-based environments that closely mirror real-world situations (Veldkamp, 2020).

1.6 Escape Room and Assessment

In recent years, a further role for educational games has been proposed in the preparation of health professions students for clinical examinations. In a study by Germa et Al. (Germa, 2020), a team-based game was used to effectively prepare dental students for an Objective Structured Clinical Examination (OSCE).

An OSCE is a performance-based assessment of clinical skills and competencies of healthcare professionals. OSCEs are a crucial part of the medical education and certification processes, ensuring that candidates can apply their knowledge in practical settings.

An OSCE is divided into a series of stations, each designed to test specific skills. Each station typically lasts for a set period, often between 5 to 15 minutes. At each station, candidates encounter a clinical scenario involving tasks such as taking patient histories, performing physical examinations, or interpreting medical data.

Through each station, OSCEs assess a variety of skills including communication, clinical reasoning, ethical decision-making, and procedural skills.

To achieve competence learners must integrate knowledge, psychomotor skills, and affective attitudes to perform clinical tasks appropriately. However, stress may reduce

performance by reducing clarity of thought and while students can learn the knowledge, it is needed to improve performance of attitudes and psychomotor skills, and it is important to support students with effective preparation and strategies to manage OSCE-associated test anxiety (Selim, 2011). ERs, with their emphasis on time limits and “against the clock” strategies and playful nature, may offer a strategy to help prepare learners for OSCEs and mitigate test anxiety.

Furthermore, ERs may have a role as an alternative assessment strategy. Several studies have proposed that ERs, in comparison to OSCEs, create a more relaxed atmosphere that, alongside working in a team, minimises stress levels and student frustration during the evaluation constituting a valid evaluation method which fosters a secure environment for the students (Muldoon, 2013; Bani-issa, 2019).

1.7 Designing Escape Rooms for Teaching and Learning

An educational ER experience hinges on various key elements that contribute to its immersive and challenging nature.

Botturi (Botturi, 2010) proposed a useful star-shaped diagram (Figure 1.4) which highlights that these elements should be consistent and connected to each other to form a seamless experience and make the ER interesting, engaging and effective.



Figure 1.4. Escape Room model according to Botturi (Botturi, 2010).

Figure 1.4: The Escape Room model, as proposed by Botturi (Botturi, 2010), uses game-based learning principles to enhance engagement and problem-solving skills in educational settings. This model involves students working collaboratively to solve challenges and puzzles within a structured time limit, promoting critical thinking, teamwork, and applied knowledge in a dynamic, immersive environment.

Designing an ER is both a creative and iterative process, and therefore it is important to maintain flexibility while adhering to a well-defined framework.

Various studies (Davis et al, 2021; Elmetproject.eu, 2020; School-break.eu 2020) have outlined key steps in ER creation, emphasizing the importance of defining clear learning objectives, structuring task progression, and ensuring a seamless blend of education and entertainment.

To design this specific gaming experience, I took the path of the “top-down design” (Bates, 2004) that focuses on the re-elaboration of the complex steps and the fluid nuances of a newborn clinical examination into the structured steps and turns of a playful environment.

Like a magnifying glass, this design process moves from general to specific, identifying in every little increment of depth of the real life scenario, clear units of time, risks and

benefits of the situation, and a standardised simplification of how to balance them to chase clear objectives and land on known rewards, all in services of a final synthesis of reality into a tight structure easy to explain, understand, navigate and tangentially, easier to control and evaluate by the GM.

With this perspective, the game mechanics exist in function of the theme and the immersion of the players into the simulated reality, so the design process becomes a true act of translation that, with the only limits of budget, props and materials, tries to deliver the real flow of the clinical examination to the players in the form of game flow. The borderline role-play nature of an ER perfectly matches the needs of this complex translation with its balance of solid perimetral structure and defined general timings in harmony with a more narrative and descriptive internal flow.

The game flow is the dynamic progression of a player's experience through the game, characterised by a delicate balance of challenge, engagement, and satisfaction. Because of the complexity of the real-life scenario, in the micro level it involves a combination of numerous and various game design elements and game mechanics tropes that work together to create an immersive and enjoyable atmosphere while pushing the flow of the game forward in a clear, sequential and chronological straight line.

An ER can have different phases and activities, and they can be organised to be sequential, parallel or more flexible, e.g. as in the event of an open puzzle sequence. They can even have hybrid solutions with several paths (Nicholson, 2016).

Naturally, crucial components of ERs are puzzles and challenges. These are at the core of the ER experience, designed to test player critical thinking, problem-solving, and teamwork skills. Puzzles can range from logic problems and riddles to physical tasks and pattern recognition, each contributing to the overall goal of solving the room's mystery within a set time limit. All the puzzles and clues should be clear and provide univocal feedback when solutions (correct or incorrect) are tested. Two key factors that can influence puzzles and enhance clarity around resolution are extensive playtesting and standardised context-specific provision of help by the game master. The availability of help and time-appropriate hints ensures that the game remains engaging and enjoyable, preventing frustration due to impeded progress.

Equipment, in the form of props and background materials, enhances the thematic experience and aids the immersivity fuelling the suspension of disbelief in the

storytelling. This attention to detail not only captures player attention but also provides subtle clues and tools necessary to solving puzzles.

When an ER is designed as an educational activity, one of the main challenges is being able to match all the activities to the intended learning outcomes, and this requires careful planning of the anticipated learning process in its entirety.

While entertainment ERs aim to attract a broad audience, educational ERs have a clearly defined target population and are tailored to align with specific learning objectives. Incorporating gamification into medical education is challenging not only because, as in any other game design process, we need to finely calibrate the difficulty level of the puzzles, but also because all the activities must align well with the curriculum. If puzzles are too easy, they can bore the participants, on the other hand overly difficult ones can lead to frustration and disengagement (Hermanns et al., 2018). Such challenges can, however, be mitigated with careful ER design and ensuring that learning objectives correspond with game goals (Veldkamp et al., 2022).

Moreover, in contrast with leisure ERs, where it may be controversial to have a high success rate, completing an educational ER provides students with a positive learning experience and ensures that solving all the puzzles meets the learning goals (Veldkamp, 2020).

Additionally, a comprehensive facilitator guide should document all aspects of the ER, including task progression, answer keys, potential hints, and the specific lock combinations required to advance through the activity. Pilot testing is crucial to refining these elements, and a structured debriefing session helps reinforce learning while gathering participant feedback to continuously improve the ER design.

These established principles had a significant influence on my approach to designing the ER. Drawing from the literature, I ensured that my ER followed a structured framework, starting with a clear set of learning objectives. I carefully planned the task sequence to reflect real-world clinical scenarios, allowing participants to engage with the material in an immersive way. I also incorporated a variety of challenge types, ensuring that each task built upon the previous one to create a logical and meaningful learning progression.

A strong clinical knowledge, combined with my deep interest in games, naturally led me to integrate practical, interactive activities into the ER design. The development of quizzes and clues was largely inspired by targeted online research, which provided

valuable insights into effective game-based learning strategies. Additionally, the practical application of these elements was influenced by existing research on similar educational ERs, particularly the works of Franco (2019) and Rosenkrantz et al. (2019). These studies offered guidance on designing engaging challenges that reinforce learning objectives while maintaining an immersive experience.

1.8 Context

1.8.1 Study Context

In OSCEs, in order to achieve competence learners must integrate knowledge, psychomotor skills, and affective attitudes to perform clinical tasks appropriately.

To the researcher's knowledge, there are no studies that specifically examine the use of educational ERs to prepare medical students for OSCE assessments. I also recognise that, more broadly, relatively few health profession ERs are evaluated beyond the level of students' perceptions (Veldkamp, 2020).

As a consequence of this, I am also interested in the impact of the ER on students' knowledge construction in relation to their curricular, in this case in the subspecialty of neonatology, topics.

Therefore, the aim of this educational ER is to closely replicate the setting and procedures of a newborn clinical examination translating into the game the practice of a newborn check.

1.8.2 Researcher Background

The researcher, a former lecturer in Neonatology at Royal College of Surgeons in Ireland (RCSI), is currently working full-time as a paediatric trainee. Beyond her professional career, she has a strong interest in game design and theory and enjoys playing various online and in-person games. Noticing a gap in the literature regarding the potential use of educational ERs to enhance OSCE performance, she decided to combine her passion for games with her experience as a clinical tutor in Neonatology to develop this study.

1.8.3 Institutional Context

The study took place within the context of the undergraduate medicine programme offered at RCSI University of Medicine and Health Sciences and involved medical students that undertook a clinical neonatal rotation at the Rotunda Hospital, Dublin.

A full-time period within a clinical team at an RCSI Teaching Hospital working in paediatrics, is mandatory for medical students in their 4th year of undergraduate study.

Through the experience of a wide-ranging clinical exposure, they have the opportunity to practise their clinical skills and take an active part in the care pathways of patients, while simultaneously gaining a multi-disciplinary experience. Student feedback is collected annually, and learners consistently request additional opportunities to learn clinical skills.

During their Paediatric rotation, medical students are required to attend a one-week placement in a tertiary centre Neonatal Intensive Care Unit (NICU) where they receive a mixture of classroom-based teaching, clinical skills training and ward time in the hospital.

The overall goal of the NICU rotation for medical students is to provide them with a thorough understanding of the basic newborn care, newborn physical examination, breastfeeding education and routine neonatal resuscitation. It is also an excellent opportunity to become proficient in understanding the presentation and the first steps of the management of infants presenting with common medical problems.

The Neonatal rotation is an integral part of the Paediatric course, and 350 students attended this rotation during the academic year 2023-24.

The traditional setting during the year is that around 250 students attend the Rotunda in staggered groups for 5 rotations in total (Rotation 1, 2, 3, 4 and 5). Every rotation is composed of two large groups of 30-35 students (Group 1 and group 2) that will rotate in the Rotunda Hospital for one week each. Every group is divided into five subgroups of 5-7 people (Subgroups A, B, C, D, E) to avoid overcrowding clinical areas.

At the conclusion of their Neonatal rotation, every medical student is required to demonstrate proficiency in conducting a newborn clinical examination and managing common neonatal medical issues safely and effectively.

1.8.4 Newborn Clinical Examination

This research took place during the mandatory neonatal rotation at the Rotunda Hospital, and throughout this time all the attending medical students are routinely trained to be able to perform an effective neonatal clinical examination.

Postnatal examinations are crucial for improving child health through several key mechanisms including allowing healthcare providers to timely identify and address health problems in newborns. Early detection and prompt management of conditions such as jaundice, congenital heart defects, or metabolic disorders can prevent the onset of severe complications.

It is also important to mention that postnatal visits are an opportunity for healthcare providers to offer guidance on nutrition, breastfeeding, and general infant care. They also offer support for parents, addressing any concerns and promoting practices that contribute to the child's well-being (Green, 2008).

The newborn clinical examination is a clinical assessment performed by trained healthcare professionals in a systematic and standardised way within 72 hours from birth, and at two and six weeks after being discharged home.

The core purpose of this important examination is to identify significant, important anomalies that might impact on the health of the baby, and it also represents an opportunity to assess and reassure parents about minor anomalies or normal variants (Murphy, 2018).

A newborn clinical examination begins by hygiene practices including handwashing or hand sanitising, a brief introduction with the parents where the doctor presents themselves and confirms with the parents the newborn's personal data. To follow, the clinician should give the parents a brief explanation of the scope of the examination and the consent to perform the same on the baby.

At this point, the health care professional should assess baby's state of alertness and responsivity, and their general appearance and then observe in the specific baby's skin, face and head, chest, abdomen, genitalia and limbs looking for signs that may be suggestive of any pathology or deviation from normal findings.

At a closer examination the head should be assessed for size, shape and swellings and the cranial sutures (metopic, sagittal, coronal, and lambdoid) should be palpated. The

clinician should also evaluate the presence (or more often the absence) of any dysmorphic feature that the baby may present, including checking the scalp, face, the eyes, the mouth with palate and lips, the neck, the clavicles and the ears.

A good cardiovascular examination includes an inspection of the chest to check for any tachypnoea or active precordium and of the oral mucosa to rule out the presence of central cyanosis.

The evaluation of femoral pulses, heaves and thrills, active precordium and hepatomegaly is performed by palpation of the clinical landmarks and through auscultation it is possible to identify the presence of heart murmurs that could be a subtle sign of an underlying cardiac condition.

During auscultation, the practitioner should also ensure that the air entry in the lungs is equal and that the infant is not in any respiratory distress.

At the stage of abdominal examination, it is important to palpate the abdomen looking for any sign of organomegaly. In newborns it is also fundamental to check for any signs of infection of the umbilical stump. The umbilical cord vessels or cord involutes over the first days from birth and usually separates at around day 7 to 14 from birth. In a newborn baby a clinician should also check for any umbilical or inguinal hernia, for the appearance of the external genitalia and should always make sure that an anus is present and patent.

In male babies it is also important to inspect the scrotum and to palpate the testes. Undescended testes are associated with torsion of the testes, and later in life can lead to reduced fertility and increased risk of testicular cancer (Leslie, 2024).

The examination of the central nervous system must comprise a behavioural status, including level of alertness and responsivity and the assessment of the tone, that is the passive resistance to movement about a joint.

The examiner should evaluate both the peripheral and the central tone. The peripheral tone includes the evaluation of baby's posture and their movement against gravity, and upper and lower limbs tone. Central tone involves eliciting head lag, ventral suspension and vertical suspension (Parish, 2018).

Barlow's and Ortolani's manoeuvres are clinical tests used to screen for developmental dysplasia of the hip (DDH) in infants (Ortolani, 1976; Barlow, 1963). These manoeuvres help detect hip instability, which can be crucial for early diagnosis and treatment.

As the last part of the newborn examination, red reflexes can be elicited looking at the baby's eyes through an ophthalmoscope.

1.9 Study Aims and Objectives

ERs have been used to promote engagement, empowering and enhancing team-building processes and quick critical and creative thinking under pressure in different contexts and for different professions (Cohen, 2021, Zhang, 2018, Franco, 2019; Roekel, 2011; Novak, 2018).

ERs are an emerging approach in health professions education, with a growing body of literature supporting their use. There are, however, important gaps in how they can be used. For example, and as highlighted previously, there are few studies that investigate their use in preparing students for OSCE assessments. To the researcher's knowledge, there are no studies that specifically examine the use of educational ERs to prepare medical students for OSCE assessments. I also recognise that, more broadly, relatively few health profession ERs are evaluated beyond the level of students' perceptions (Veldkamp, 2020). As a consequence of this, I am also interested in the impact of the ER on students' knowledge construction in relation to their curriculum, in this case in the subspecialty of neonatology, topics.

The scope of this project is to investigate the potential of using an ER as an educational activity. The aim of the educational ER itself is to support learning to around a newborn clinical examination.

The overall research question for the study is: "what is the impact of an educational ER on the performance of medical students enrolled on a neonatology rotation?"

Primary outcomes of this research project are:

- to explore game-based learning in shape of an ER as a new educational tool to deliver an effective educational activity and to evaluate if ERs can facilitate the acquisition of knowledge, and clinical skills in undergraduate healthcare profession students.

MCQs are a well-established, reliable method of assessing knowledge, and the OSCE outcomes will assess students' clinical skills, attitudes, problem-solving abilities, and their application of knowledge within simulated environments.

- to assess ER effectiveness in engaging, empowering and enhancing the team building

process and producing quick critical and creative thinking under pressure.

As a secondary outcome I would like to evaluate the role of ER interactive game-based learning experience in facilitating communication, leadership, and teamwork competencies in undergraduate healthcare profession students.

1.10 Chapter Summary

Games have been an integral part of education for centuries, providing a dynamic and interactive way to facilitate learning. Over time, the use of games in educational settings has grown, becoming a cornerstone of modern pedagogy. This turn reflects a deeper understanding of how play can enhance cognitive and social development.

Educational game-based learning is based on a number of theoretical foundations that explain the psychological mechanisms by which gamification achieves its positive outcomes (Krath, 2021).

In recent years, ERs have gained popularity as a powerful educational tool. These immersive, scenario-based games challenge participants to work together to solve puzzles and complete tasks within a set timeframe, providing a stimulating environment that demands active participation. ERs are effective at promoting engagement, developing essential skills such as teamwork, critical and lateral thinking, and problem-solving. Additionally, the collaborative nature of ERs nurtures leadership abilities and communication skills, making it a valuable educational tool in the creation of more engaging, interactive, and effective learning experiences.

In my opinion, educational ERs have significant potential to enhance OSCE performance by creating a dynamic, immersive environment that mirrors the high-pressure, problem-solving scenarios encountered in clinical practice.

Therefore, the primary objective of this study was to evaluate if the pressure and the impact of an educational ER could be used as a new educational tool to improve OSCE performance of clinical medical students.

This project also aimed to evaluate the effectiveness of using an ER to deliver an effective educational activity and to evaluate if it can facilitate the acquisition of knowledge, leadership, and teamwork competencies in undergraduate healthcare profession students.

Also, this research explored the possibilities offered by the gamification of teaching and learning as a new educational tool to engage, empower and enhance the team building process and quick critical and creative thinking under pressure.

2. MATERIALS AND METHODS

2.1 Chapter Overview

This chapter outlines the materials and methods used in the study, providing a detailed description of the research process. It begins with an introduction to the study's framework, followed by an explanation of the study design, recruitment strategies, and population criteria. The eligibility criteria and research ethics are also discussed to ensure the study's integrity and adherence to ethical standards.

The chapter then focuses on the intervention, covering all the stages of the development of the educational ER, and its alignment with the intended learning outcomes, highlighting its educational significance.

2.2 Study Design

In healthcare training there are many situations in which role play (that in the gaming community is considered as the father of ERs and often an extra level of enrichment and engagement for the ER experience) and immersion in simulated scenarios are effectively used in teaching and examinations (Xu, 2023; Goothy, 2019, Lane, 2007, Mann, 1996; Charlton, 1993; Teerawongpaibroj, 2024; Bharti, 2023; Benko, 2023; Yee, 2024; Bosse, 2011; Ong, 2022; Manzoor, 2012), however, in literature there is paucity of research evaluating whether educational ERs could be valuable educational strategies to aid students' preparation for OSCE assessments.

This project investigated the potential of using an educational ER as an educational activity, to determine whether it could aid in the acquisition of knowledge and clinical skills among undergraduate healthcare students, to assess its impact on the OSCE performance of clinical medical students and to investigate its potential as an innovative educational tool to enhance engagement, empowerment, teamwork, and rapid critical and creative thinking under pressure.

To explore these research questions, I designed a prospective, exploratory, randomised controlled trial (RCT) using a mixed method study to analyse data from students attending their mandatory Neonatal rotation that volunteered in experiencing the educational ER designed for this study.

The RCT aims to establish causal relationships and evaluating the effectiveness of the intervention, however this study design can inadvertently create feelings of exclusion among participants who may have feelings of missing out on a potentially beneficial learning opportunity and the fun part of the experience.

To address this ethical concern, the protocol includes offering the ER to the control group after data collection is completed.

2.3 Recruitment and Population

Participants were recruited via email by RCSI course coordinators between all the medicine undergraduate training students (4th year) undertaking their neonatal rotation in the Rotunda Hospital, prior to beginning their academic year in 2023.

Recruitment to this study was on a voluntary basis and the students were informed about the nature of the project.

A participant information leaflet was sent via email by the course coordinators two months prior to commence the academic year, to give students the time to read it and ask questions if needed.

The information leaflet clearly explained that the research project involved the design and evaluation of an educational ER. Consent was asked during their attendance in the Rotunda Hospital, and it was entirely voluntary. Those students that agreed to take part in the study were randomly assigned to two groups, Group Escape Room Teaching (GER) and Group Routine Teaching (GRT).

To streamline logistics and maintain equal numbers in both the GER and GRT groups, each participant who agreed to take part in the educational ER was assigned a one-hour time slot based on their subgroup's timetable. Upon arrival at their designated activity slot, they were randomly allocated to either GER or GRT in a 1:1 ratio.

The subgroups from GER became escape-room teams and during their week in Neonatology they participated in the escape-room experience in addition to their traditional teaching for a total duration of 1 hour, and a subsequent debrief of about 15–30-minute following the experience.

GRT subgroups availed of 1 hour of protected time to study and practise their skills on a mannequin in addition to the traditional teaching schedule planned for their rotation.

2.4 Eligibility Criteria

Eligibility requirements to participate in the educational ER included RCSI Medicine students due to attend the neonatal teachings in the academic year 2023-2024.

There were no requirements with respect to clinical experience or prior clinical training. Exclusion criteria for research participants included RCSI undergraduate students that were not due to undertake the neonatal course in the academic year 2023-2024, RCSI students that were not allocated to the Rotunda Hospital during their Neonates rotation, and any other student attending the hospital from a different University.

2.5 Research Ethics

This research project was approved by the RCSI Research and Ethics Committee (REC202211032) (Appendix 5).

For this study, all RCSI students scheduled to attend the Neonatal rotation at the Rotunda Hospital during the 2023-2024 academic year were contacted via email by the course coordinators. They were informed about the study and the opportunity to participate. A participant information leaflet (Appendix 2) was attached to the email to provide detailed information about the study.

Written consent to participate in the study (Appendix 3) was requested on the first day of the students' attendance at the Rotunda Hospital, ensuring that they had sufficient time to read the information leaflet and make an informed decision regarding their participation. The recruitment materials clearly stated that students who chose to participate would contribute to research on the educational benefits of ERs in the context of interprofessional practice and teamwork. It was emphasised that participation in the project would not influence their final evaluations in any way.

The recruitment information also made it clear that students could decline to participate or withdraw from the study at any time without facing any consequences. To prevent potential inequalities between the two groups, GRT members were offered the chance to participate in the ER activity at the end of their rotation, following the completion of mock exams and with prior coordination with course coordinators.

Participants were informed that the outcomes of the mock exams were intended solely as feedback and would not affect their evaluations or final marks. All data collected for

the study were gathered in a pseudo-anonymous manner and will be retained only until the publication of the results. Overall, data will be stored for no longer than five years, after which it will be securely destroyed.

Once the study is published, the file containing the data will be permanently deleted by the researcher. The research team is committed to adhering to the principles of the General Data Protection Regulation (GDPR), with detailed policies and systems in place, including oversight by a Data Protection Officer to ensure compliance with data protection regulations.

The data collected will be used exclusively for the specific purposes of this research. This means that the data will not be processed for any purposes other than those originally intended when it was collected.

2.6 Intervention:

2.6.1 Game Design

The design of the educational ER created for this research project was oriented towards simulating a newborn clinical examination environment by providing a team-based, hands-on exploration of a routine neonatal baby check in all its steps.

Since volunteer participants in an educational ER are often learners with a predisposition towards gaming, with an augmented tendency to engage and enjoy game-related activities, and a specific attitude towards playing for learning, a learner analysis was performed in order to support the creation of content that is relevant, engaging, and accessible for everyone, with the aim of enhancing the overall effectiveness of the learning experience (ref Morrison). To minimise differences due to personal inclination and preference towards the gaming activity, all the puzzles of the designed ER rely on medical knowledge and are specific to the learned course content, with the assumption that students developed the knowledge needed to successfully complete the educational ER during their week of attendance in the Rotunda Hospital.

All the activities are designed to ensure that the outcomes depend on the students' acquired knowledge and critical thinking skills rather than their mere ability to solve and decipher clues.

This helps to ensure that completing the activity accurately reflects how well students

understand and remember what they learned during their week of attendance at the hospital.

One of the most widely used models for identifying learning preferences is the VARK model, which categorizes learning styles into four sensory pathways: visual (V), aural (A), read/write (R), and kinesthetic (K) (Fleming, 2006; Rajgor, 2006).

In designing this educational escape room (ER), a variety of activities were incorporated to accommodate all four learning styles, with the goal of enhancing student engagement and improving learning outcomes and efficiency. Visual learners, who learn best through seeing, benefited from numerous visual cues embedded in the ER. Likewise, read/write learners were engaged through keywords and puzzles that required precise written responses.

The game's emphasis on teamwork and peer interaction facilitated communication and reinforced concepts through repetition, supporting auditory learners. Lastly, kinesthetic learners, who learn best through hands-on experiences, found the ER environment particularly well-suited to their learning style, despite the challenges typically associated with this mode of learning.

To engage players, effort was made to include in the ER a rich and diverse variety of puzzles and riddles of an appropriate difficulty level for the students. Also, the narrative was present throughout all the experience, and it is integrated into the different challenges of the game. The flow maintained fluidity, with each clue connected to the next challenge and serving as an integral component of the entire game (Franco, 2019).

Intense play testing was performed on the ER activity. Gameplay and game testing are essential in shaping and refining the development of a game (Bates, 2004; Oxaland, 2004). They help delineate the game's vision by showing what works for players in terms of mechanics, immersion, and engagement.

Gameplay refers to the way players interact with a game's mechanics, challenges, rules, and objectives. It essentially defines the player experience. Key elements of gameplay that help delineate the game include the mechanics of the game, that ensure the ER is fun, balanced, and functions as intended.

Game testing is the process of rigorously playing and evaluating the game to identify design flaws, and usability issues. It ensures the game functions correctly and provides a polished experience. One of the main purposes of game testing is to find bugs or

issues in the code that could break the game or cause unintended behaviour. Game testing helps also to refine the balance of mechanics such as puzzle difficulty. testers provide feedback on what is too hard, too easy, or simply not fun, for this, game testers provide insights into whether the game is enjoyable over longer periods and whether if players lose interest after a few steps, or if the game keeps them engaged.

Together, gameplay and game testing ensure that the final product is not only technically sound but also enjoyable, coherent, and true to the original design goals.

The time limit in ER provides a sense of urgency and heightens the pressure, creating a unique educational environment to test the skills and teamwork of those participating. It enhances student learning on how to manage the time available and how to prioritise their resources accordingly (López-Pernas *et al.* 2022).

Researchers in the domain of educational ERs have highlighted that the restricted time involved can give the players' actions a sense of urgency (Veldkamp *et al.* 2022). It is possible that the time-sensitive learning environment of the escape game can provide a valuable space for students to practise critical and creative thinking under pressure and offer an opportunity to prepare for OSCE assessments and, beyond this, provide an authentic experience of time pressure to support their capacity to cope with stressful and time-critical real-life circumstances.

With respect to duration, there is some evidence to suggest that a one-hour duration is typical for ERs. For example, a recent scoping review in this domain highlights that 78% of educational ERs last one hour or less (Fotaris, 2019).

The duration plays a crucial role in ensuring an engaging and effective experience and for this research project, I adopted the one-hour time frame as I felt it hit the right balance between entertainment, challenge, and operational feasibility.

After play-testing different spans of duration, I noticed that a shorter game felt rushed, while a longer one tended to lead to frustration, loss of momentum and excitement. In my experience, the 60-minute duration ensures that players remain mentally stimulated while fully enjoying the game.

This perfectly aligns what is the usual time of an ER in the environment of pure entertainment who focuses precisely on keeping a high level of interest, engagement, excitement and fun from the users.

Additionally, practicality and efficiency influenced my decision as this length of the game

enables multiple sessions per day, while allowing the time to reset the setting for the next group.

Due to limitations of space and the lack of an exclusively dedicated room for the ER, all the props were designed to fit in five large, black, lockable boxes. This compact, portable version was designed as a self-contained kit that could bring the immersive experience of an ER to any location.

The first box is introductory and contains key props that the players will require at a later stage of their progression through the game. The other four boxes are designed to facilitate students' exploration of each of the main body systems examined in a newborn clinical check. This arrangement aligns with that of the OSCE station organised as part of the routine students' examination.

To make this information clearer, every box has the symbol of one of the main systems explored through the game pictured on the lid. The different systems are central nervous system (CNS), ear, nose, and throat (ENT), cardiovascular system (CNS) and gastrointestinal system (GI) including the genitourinary tract.

A game master (GM) is present in the room for the whole duration of the game, to closely monitor the players and to keep track of their progress.

It is GM's role to maintain the immersive atmosphere of the ER, ensuring that the environment stays engaging and fun. The GM balances the game, providing assistance without giving away the solutions outright and also helping teams if they get stuck or request help. In the event that technical issues arise during the game, the GM makes sure that those are quickly addressed to ensure a flawless continuation of the game.

During each session there are four levels of assistance available to players, and to help immersivity they are provided as a call to a peer or senior colleague. The first, basic level is to "make a call to the SHO", followed by calling the registrar, a more experienced colleague, then calling the Consultant, the most senior help available. Lastly, each team could avail of the option to "Google the question". Initially the intent was to stratify each help given depending on the level of seniority requested. For example if a team requests the help of the Senior House Officer (SHO) the level of support given is less than if they call the Registrar or the Consultant that are more experienced medical figures. In the case that the team had chosen an online search engine to find the answer needed, they should have received a stream of information, as it happens when study material is looked up on Google. Instead, at the end, to

standardise the assistance and to simplify this task for the GM, a decision was made to maintain all the supports at the same level. This means that there was no difference in the quality of the help provided. The SHO/Registrar/Consultant/Google nomenclature was maintained to make it easier for the GM to record them and to create a sense of urgency in the players. Using the help would not penalise the team but it was time-consuming. This maintains the educational value of the senior support and provides a supportive environment where players can learn and improve their problem-solving skills and learn through the game.

Once the game phase is over, students consolidate their learning by reflecting on the game experience through a debriefing that will complete the learning cycle, transforming the subjective knowledge developed during the game into knowledge that can be used in other contexts (Botturi, 2010). Post-simulation debriefing and reflection practice are some of the most effective components of simulation-based education and form the cornerstone of the learning experience in the medical simulation setting. The debriefing stage is essential as it allows learners to make sense of their actions and interactions during gameplay, gain insight into learning outcomes, and relate the activities to real-life situations (Nicholson, 2012; Keiser, 2021; Deason, 2013). However, despite the recognised benefits of debriefing, a high proportion of ER games fail to include it due to reasons of time limitations, facilitator confidence, and resourcing issues (Kolbe, 2015).

2.6.2 Escape Room Development and its Alignment with the Intended Learning Outcomes

In ERs, puzzles can be organised in a pure open, sequential or path-based manner or they can have a more complex, hybrid structure, such as a pyramid.

The ER designed for this research project has a sequential structure where participants need to solve one puzzle after another in order to unlock the next step of the game.

2.6.3 The Rules

Every game has rules that players must respect to ensure a safe, fair, and enjoyable experience for all participants, this is no different for an educational ER.

Players are informed prior to the start of the timer about the rules:

Players have 60 minutes in total to complete the game.

Players have access to four levels of help during the game. Using these helps does not penalise the team, but it consumes time. Each help can only be used once, and the team must communicate with the Game Master to receive assistance for specific queries or challenges.

Props must be handled with care and the Escape Room is not meant to be physically demanding and no force is required for any of the puzzles.

Every puzzle is propaedeutic to the next one.

Mobile phones are allowed to be used exclusively as a calculator.

Some of the props found in a box may be used immediately, some others may be used later.

There are no clues in the room or in the furniture.

2.6.4 The Theme

The ER theme was explained to each team of players at the start of the game: they were a team of medical trainees stepping into the role of Senior House Officers (SHOs) in the Neonatology department. The mission was to perform a thorough baby check on a newborn to ensure the baby's health and identify any potential issues. The newborn in the scenario was stable but requires immediate and accurate assessment.

To set the tone and increase immersivity, on the first locked box there is a message with the following clear indication:

"The midwife calls you in an evident state of agitation.

A baby has been missed from the routine discharge checks and now you have only 60 minutes to complete the baby check."

Chart #679"

The theme is appropriate and motivating for the students that are expected to perform a detailed neonatal discharge examination as part of their OSCE.

Technical medical vocabulary and terminology related to the theme are used to integrate the narrative to the game.

A timer of one hour (Figure 2) was started by the GM as soon as the team playing starts reading the message on the box.

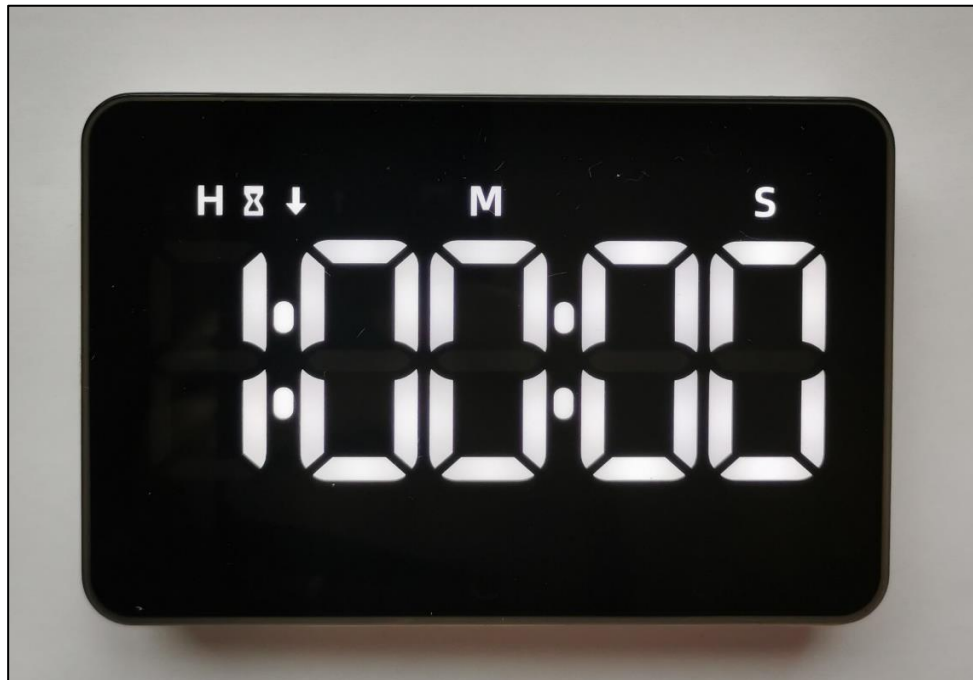


Figure 2. One-hour timer.

Figure 2. Timer of one hour that starts as soon as the participants start reading the first clue.

2.6.5 Boxes and Puzzles

The game begins with students reading the introductory message containing their first clue, the numeric code #679, and using it to unlock the first box.

2.6.5.1 Box n.1 – Introduction to The Game

In box number one the players will firstly find an *open* folder (folder #1) containing four cards (Figure 2.1).

On each card there is a number and the description of one of the four steps to approach the patient prior to starting the examination.

Participants must arrange the cards in the correct sequence of events that a doctor should perform before starting a clinical examination: washing or sanitising hands, introducing oneself, asking for permission to examine the patient, and explaining your role and the purpose of the examination.

Students are required to complete this task at the beginning of each box. While the cards may vary slightly from one system to another, the initial steps must always be

completed in the first folder of each box to unlock the next folder or clue.

This moment serves as a crucial analysis opportunity later in the reflection/debriefing stage when learners will reflect on the activity.

In an educational ER, locks symbolise barriers or challenges that learners must overcome to access new knowledge or progress in their learning journey. Each lock represents a specific concept, skill, or piece of information that students need to unlock through problem-solving, critical thinking, and collaboration.

When learners successfully open a lock, it represents the moment of acquiring or understanding new knowledge. This action is symbolic of the learning process, where effort, persistence, and the application of existing knowledge leads to new discoveries and deeper understanding. Each unlocked lock is a milestone in the learning journey, marking progress and achievement.

The first folder of each box is intentionally left open as it symbolises that certain foundational knowledge, or skills are readily accessible without requiring special effort. Learners only need to think actively about basic concepts, and this reflects the ease with which foundational knowledge can be acquired.

In this case the only requirement is to actively think about the order of events. As the game progresses, performing these steps will become more automatic for the participants. This reflects the real-world healthcare environment where clinicians should become so accustomed to routine hand hygiene and proper patient approach that they perform these tasks automatically, without conscious thought.



Figure 2.1. Contents of Box n.1: doll, magnifying glass with transparent magenta lens, cards with the appropriate steps to perform to approach the patient prior to starting the examination.

Figure 2.1. Props that participants to the ER find in their first box. It includes four cards each with an introductory moment to perform before the newborn examination, including washing the hands, introducing yourself, asking for permission to examine the baby and explaining what you are going to do next. In the box there is also a doll with several numbers on the skin, and a magnifying glass with a magenta-coloured lens; props that will be used by the participants at a later stage of the game.

Together with the folder, players will also find a magnifying glass with lens made of a transparent magenta acetate sheet, and a doll, wrapped in baby clothes, with multiple numbers written on the surface of their body (Figure 2.1).

Both items will be used at a later stage of the game.

2.6.5.2 Box n. 2 – The Central Nervous System (CNS)

Box n. 2 is intended to explore the neurological examination of the newborn.

On the lid, a stylized image of a brain prompts the students to focus on the CNS examination (Figure 2.2).

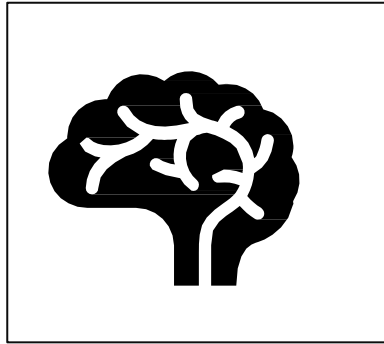


Figure 2.2. Brain image applied on the top of Box n. 2.

Figure 2.2. Icon of a brain applied on top of the second box to introduce the students to the system that they are going to explore through the game. In this case CNS.

The first envelope contained in this box (folder #2) is, as already mentioned, an open file, and contains three cards to be lined up in the best order.

One card includes “wash your hands, introduce yourself”, the second card is “ask for permission”, the third card contains “level of alertness, posture, dysmorphic features” (Figure 2.3).

This time an extra level of knowledge has been added: students are invited to order not only the first introductory steps, but to engage with a further knowledge about neurological general inspection.

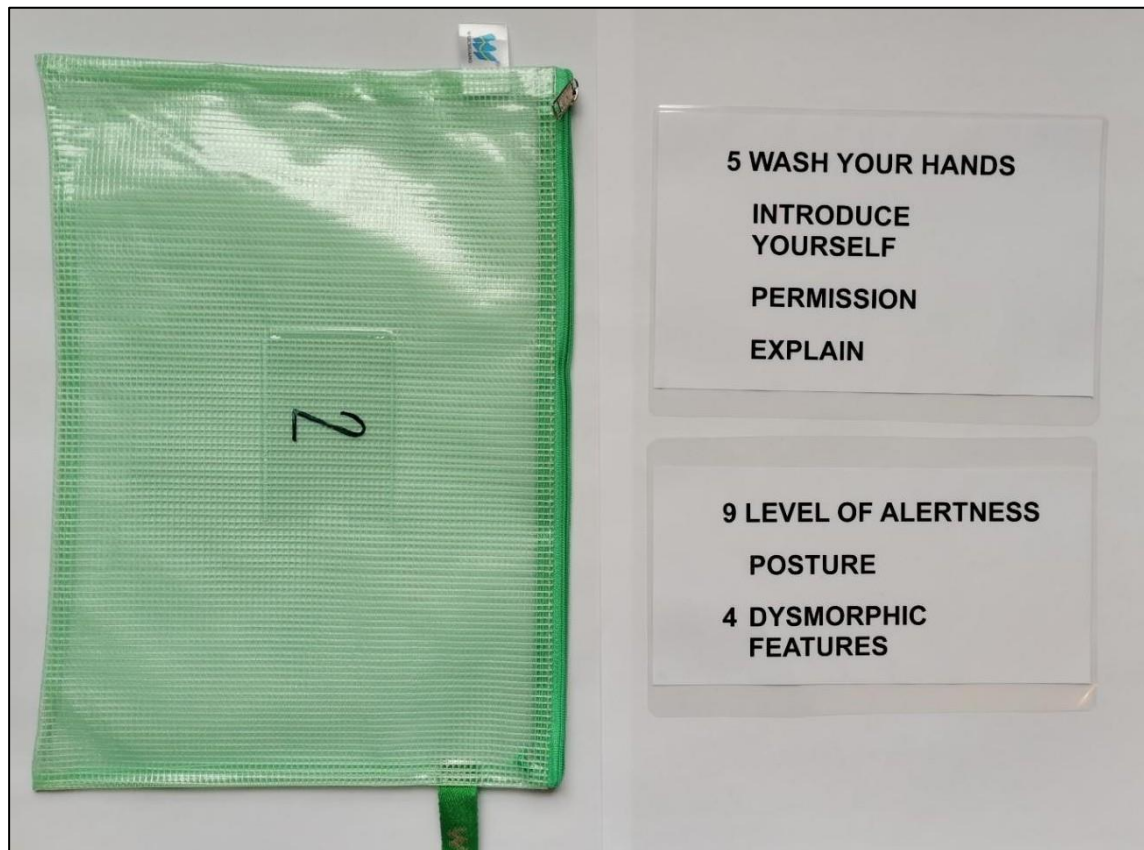


Figure 2.3. Contents of Box n.2, Folder n.2: cards with the appropriate steps to perform to approach the patient prior to starting the examination.

Figure 2.3. Folder number 2 and its content including two numbered cards, one with the four introductory moments to perform before the newborn examination including washing the hands, introducing yourself, asking for permission to examine the baby and explaining your next steps and the other with moments specific to the neurological examination such as the assessment of the level of alertness and the posture (of the newborn) and the presence of eventual dysmorphic features.

In this case the general inspection is focussed on the CNS to reinforce the underlying theme of Box n.2.

The numbers on the side of each card, ordered in the correct way, give players the code to open the next folder, where they will find a measurement tape (Figure 2.4).

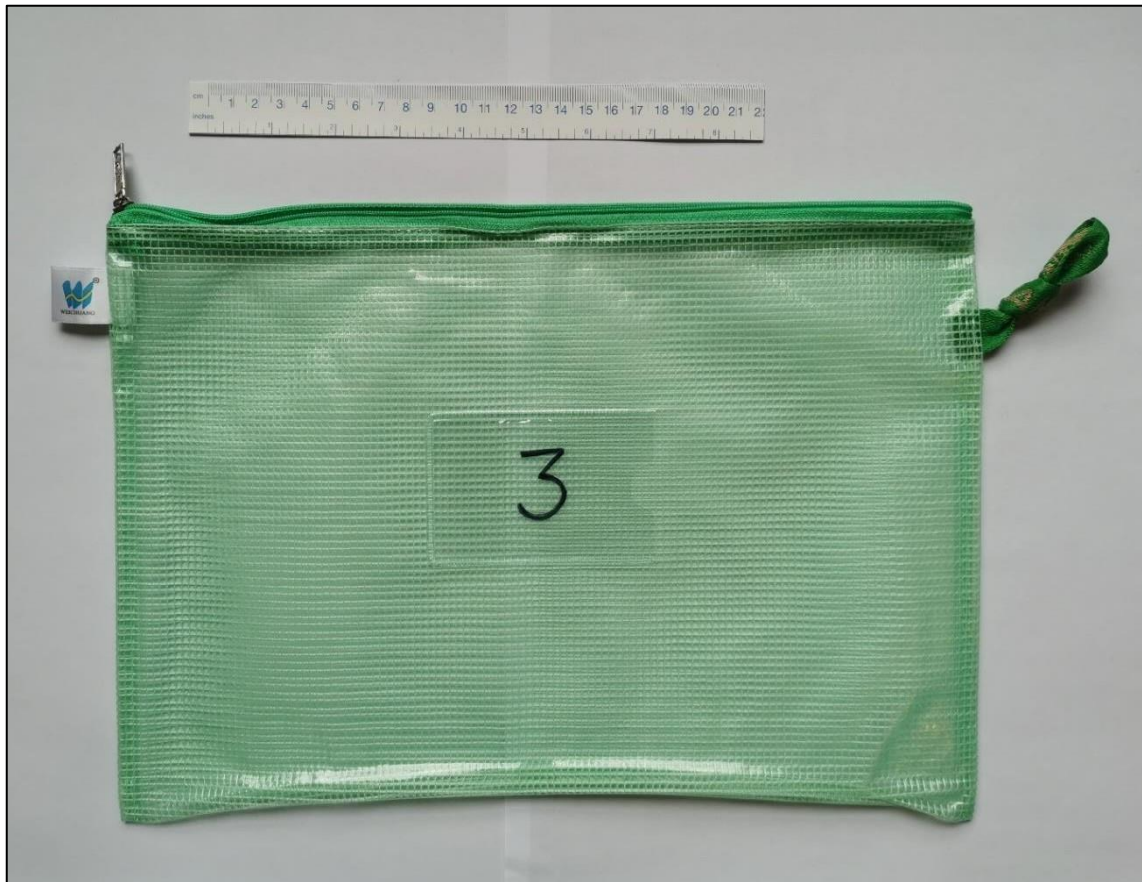


Figure 2.4. Contents of Box n.2, Folder n.3: measurement tape.

Figure 2.4. Folder n.3 and its content: a measurement tape, needed to perform the occipital frontal circumference, essential part of the newborn assessment.

The code for the next folder (folder #3) is the number of centimetres of the occipito-frontal circumference (OFC) of a neonatal head, measured from the most prominent part of the forehead around the widest part of the occiput.

In medicine, a minimal intra-operator variance of the measurement is usually accepted in OFC measurement, and therefore in this section the GM has the role to reassure the students on their findings if there is a minimal discrepancy (in terms of 1-2 millimetres).

In the successive folder (folder #4), participants find a baby-shaped silhouette made by semi-transparent paper (Figure 2.5). On this prop, “scarf test positive” is written. This indication should lead the students to perform a cross-body adduction test on the given support (Amiel-Tison 1968, Morgan et al 1988). The test is performed by passively bringing the patient's hand and pulling it to the opposite shoulder (like a scarf, from which derives the name of the test). In a newborn with normal tone, the hand should not go past the shoulder and the elbow should not cross the midline of the chest.

On the arms of this bi-dimensional newborn figure there are also two sets of symbols: once the player performs the correct manoeuvre (scarf test positive), these signs will perfectly align revealing the code that opens the lock. If the players perform a negative scarf test, the prop will give an incorrect code that will not open the lock, prompting the students to reason upon their actions and perform the correct procedure.

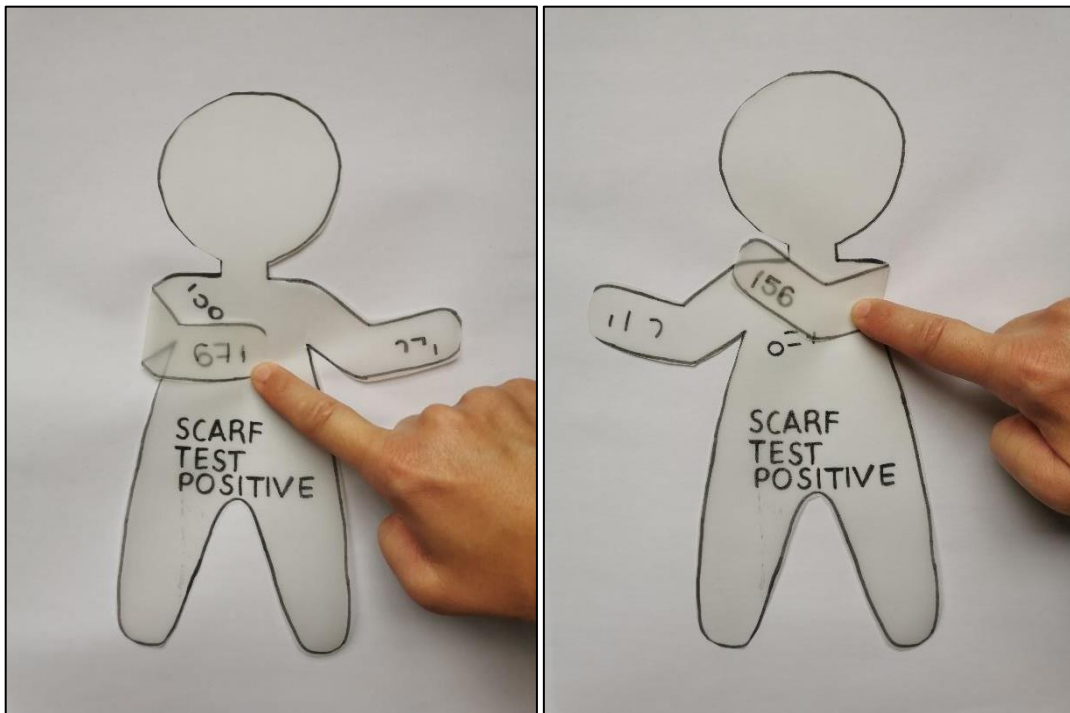


Figure 2.5. Contents of Box n.2, Folder n.4: baby-shaped silhouette made by semi-transparent paper to perform the scarf test.

Figure 2.5. Stylised image of a newborn cutout from a semi-transparent paper. On the image there is the indication “scarf test positive” and various signs. The signs will perfectly align giving a numeric clue once the scarf test is performed. The number appearing at the performance of a negative scarf test is different from the one that appears at the completion of a positive test and only the finding from a positive scarf test is the key to open the next lock.

In folder #5, players will find numbered cards with stylised pictures of the newborn's tone assessment including posture, head lag, vertical suspension and ventral suspension (Figures 2.6, 2.7, 2.8, and 2.9) (Mercuri, 2005). For each assessment there will be one card showing a normal finding and one with an abnormal finding.

In neurologically normal newborns, the upper and lower limbs naturally assume a slightly flexed posture and move freely against gravity.

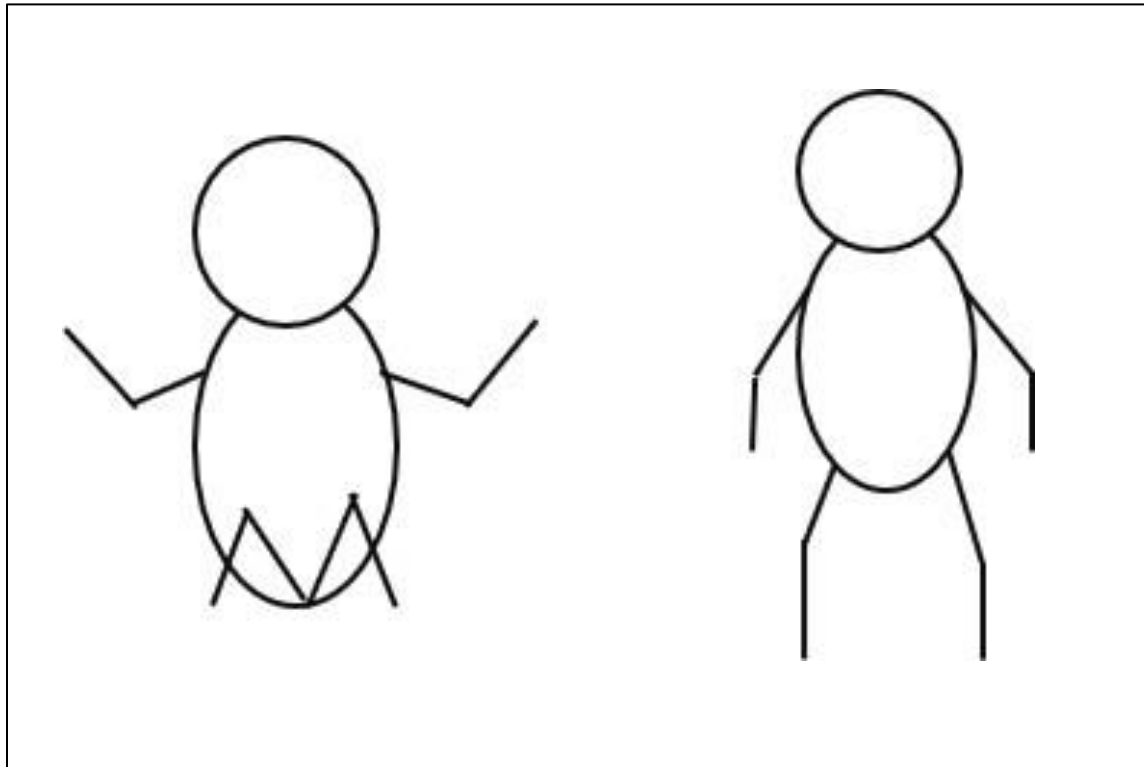


Figure 2.6. Contents of Box n.2, Folder n.5: representation of newborn posture. On the left, neurologically appropriate posture, on the right, abnormal findings. Adapted from Mercuri 2005 (Mercuri, 2005).

Figure 2.6. Two of the eight cards for newborn tone assessment included in Folder 5. Each card has a picture of a stylised representation of the newborn posture. The image on the left represents an infant in semi flexed position, normal finding in neurologically appropriate newborn, on the contrary on the right side the image shows extended upper and lower limbs in keeping with an abnormal finding (hypotonia).

When assessing an infant's central tone, the clinician begins by evaluating head lag. This involves gently but firmly holding the baby by the forearms and pulling them into a sitting position. Initially, there should be a mild head lag, followed by the infant lifting their head to hold it upright momentarily.

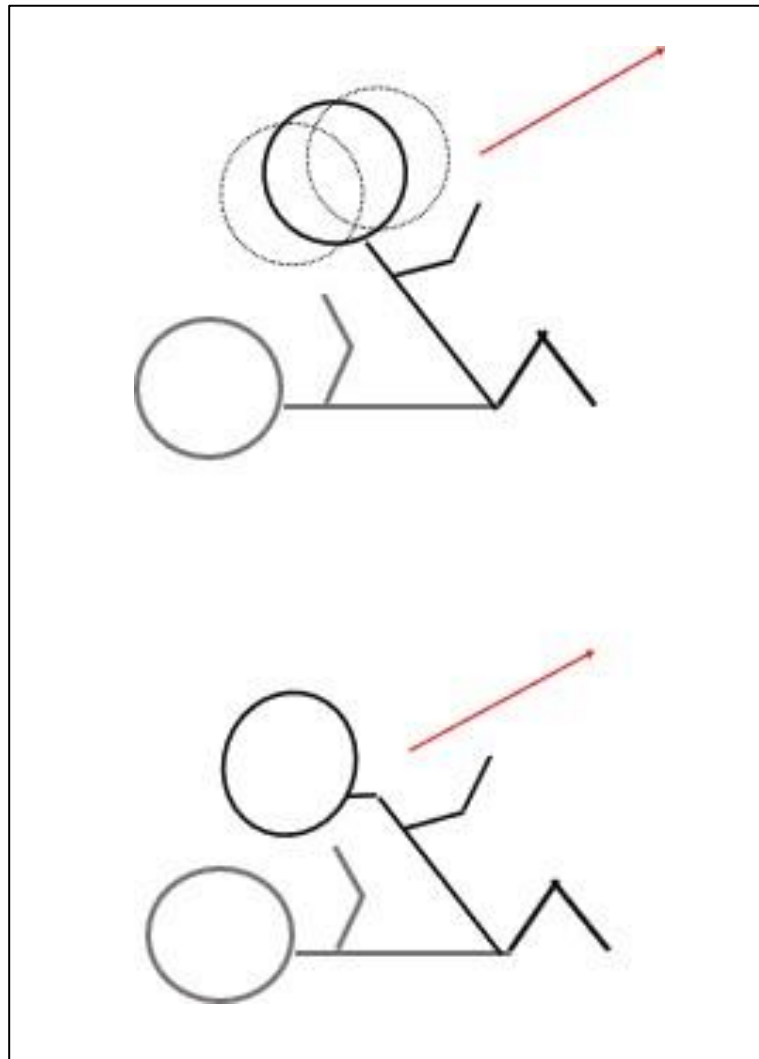


Figure 2.7. Contents of Box n.2, Folder n.5: above, neurologically appropriate head lag, below, abnormal findings. Adapted from Mercuri 2005 (Mercuri, 2005).

Figure 2.7. Representations of newborn head lag: the picture on top illustrates a physiological finding, while the one on the bottom a pathological one. When gently pulled from a lying to a sitting position, newborn's head will lag behind due to underdeveloped neck muscles, which is a normal finding in this age group, as pictured in the image on the top. In the picture below, on the contrary, the head is completely limp with no attempt to lift, and this sign suggests hypotonia. These are two of the eight cards for newborn tone assessment included in Folder 5.

Next, the clinician tests vertical suspension by holding the infant under the armpits and lifting them into a vertical position with their legs hanging down. The infant should remain suspended without slipping through the examiner's hands.

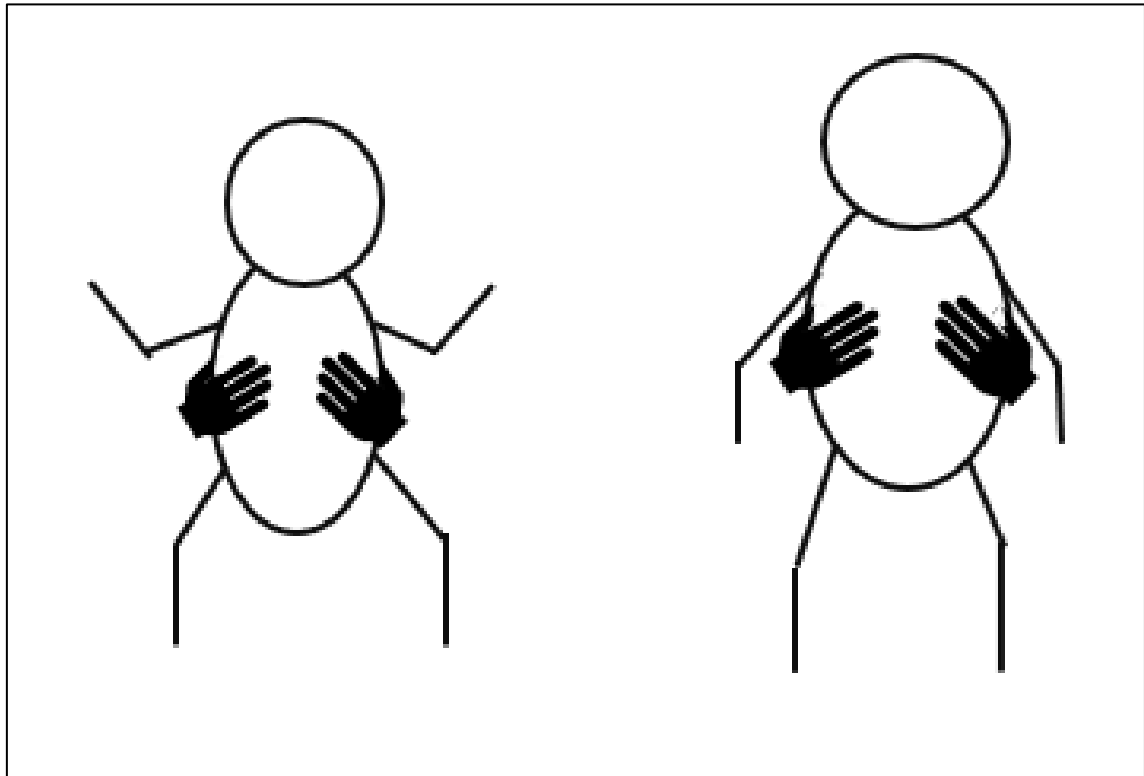


**Figure 2.8: Contents of Box n.2, Folder n.5: on the left, neurologically appropriate newborn tone on vertical suspension, on the right, abnormal findings.
Adapted from Mercuri 2005 (Mercuri, 2005).**

Figure 2.8. These are pictograms of the vertical suspension of two newborns. These images are included in the eight cards for newborn tone assessment included in Folder 5. A neurologically appropriate newborn, as the one depicted on the left, when lifted in a vertical suspension shows flexion in the arms, legs, and hips, with mild resistance to gravity. In contrast, abnormal findings during vertical suspension such as the ones shown in the image on the right include arms and legs dangling loosely and demonstrating little to no resistance to gravity.

Lastly, in ventral suspension, the infant is turned prone and lifted off the cot by placing a hand under their chest. In a normal examination, the findings should include a straight back, the baby's head in line with the body, and flexed limbs.

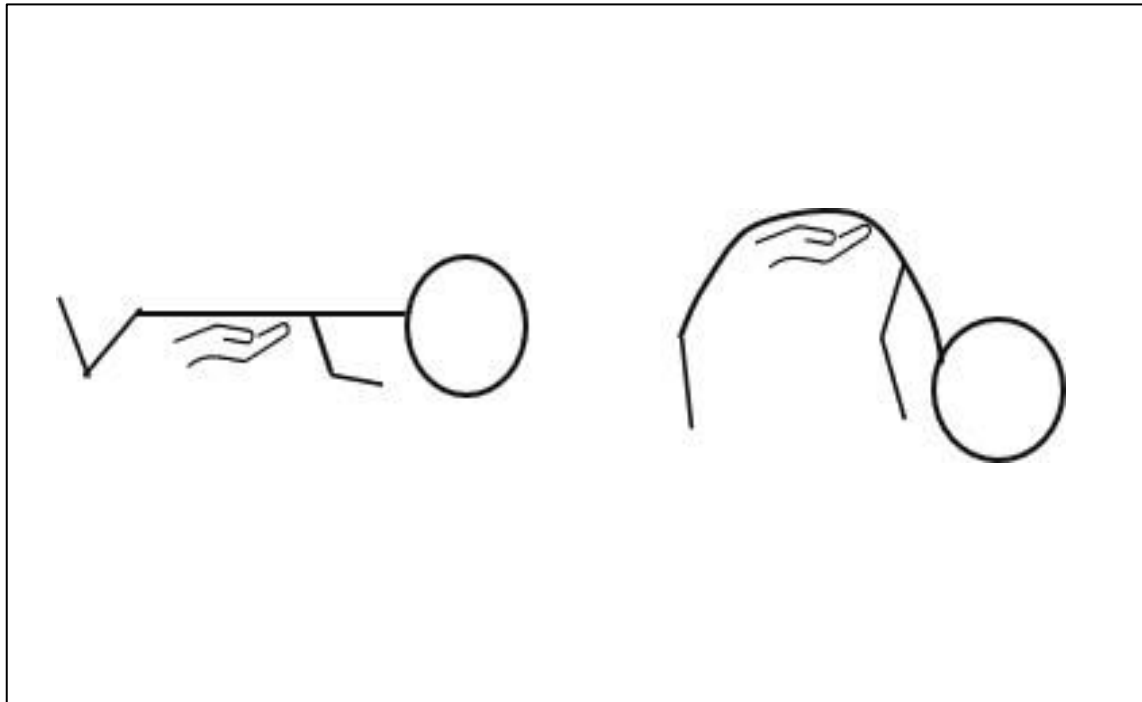


**Figure 2.9. Contents of Box n.2, Folder n.5: on the left, neurologically appropriate central tone, on the right, abnormal findings.
Adapted from Mercuri 2005 (Mercuri, 2005).**

Figure 2.9. Pictograms of the newborn ventral suspension assessment included in Folder 5. This test evaluates a newborn's muscle tone and neurological development. In this test, the newborn is held prone in the air, with support from the examiner's hand under the abdomen. In a neurologically appropriate newborn, there should be some degree of flexion in the arms, legs, and neck. The baby may make attempts to lift the head momentarily, and the limbs should remain flexed toward the body, as pictured on the left. In case of reduced tone, findings will include limbs dangling down, little to no head control, and no resistance to gravity as shown in the right image. These findings are abnormal.

Performing these manoeuvres in the correct order is crucial. When done smoothly, the baby is lifted only once, minimising the risk of upsetting them.

In the same folder (#5), participants will also find a crossword puzzle and a riddle.

ACROSS

2 - to be performed in all 4 extremities

3 - symmetrical abduction - adduction of upper limbs

4 - reflex start when the palate of the baby is touched

5 - baby appears to take steps or dance when held upright

DOWN

1 - reflex starts when the corner of the baby's mouth is stroked

2 - also called truncal incurvation reflex

THE RESULTS IN THE REFLEXES "○" WILL GUIDE YOU TO THE NEXT STEP OF THE CLINICAL EXAMINATION

ORDER THE

○ ○ ○ ○ ○ ○

FINDINGS

Figure 2.10. Contents of Box n.2, Folder n.5: crossword puzzle and riddle.

Figure 2.10. Content of Folder n.5: the crossword puzzle on the left contains descriptions of primitive reflexes (like the Moro reflex, rooting reflex, etc.) as clues. A few predetermined squares are marked with red circles. The solution of the crossword and filling in all the correct answers, highlight six letters that combined will form the anagram of the word "normal". After solving the crossword and finding the word "normal," players are prompted to write it into a riddle that implies that the next task is related to organizing or understanding normal newborn tone. The players must now order the normal findings related to a newborn's tone assessment based on the clues (cards) they have previously found.

The crossword has the descriptions of the primitive reflexes as definitions and in its grid, there are few red circles marked in determinate squares. Once all the solutions are written in the given place, six different letters will be highlighted. If put together, these letters will form an anagram that, if solved, will give the answer "normal".

Players are prompted to write the word found through the crossword into a riddle that will give the hint to the next step of the quiz: ordering the normal findings of the newborn tone assessment. The riddle states:

“The results in the reflexes O will guide you to the next step of the clinical examination.

Order the O O O O O O findings.”

2.6.5.3 Box n. 3 – The Cardiovascular system (CVS)

Box No. 3 focuses on the examination of the newborn’s CVS, as illustrated by a heart icon on the lid of the box (Figure 2.11).

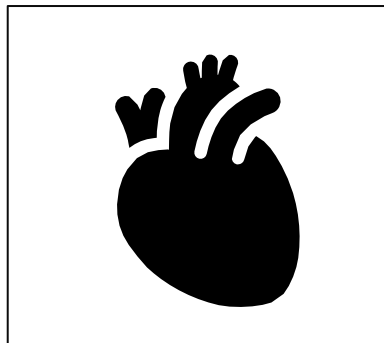


Figure 2.11. Heart image applied on the top of Box n. 3.

Figure 2.11. Icon of a heart applied on top of the box number three to introduce the students the box content: the CVS.

The first folder of the box, folder #6, is open and contains the first introductory steps of a newborn exam, including a brief description of a general assessment in relation to the CVS examination (figure 2.12).

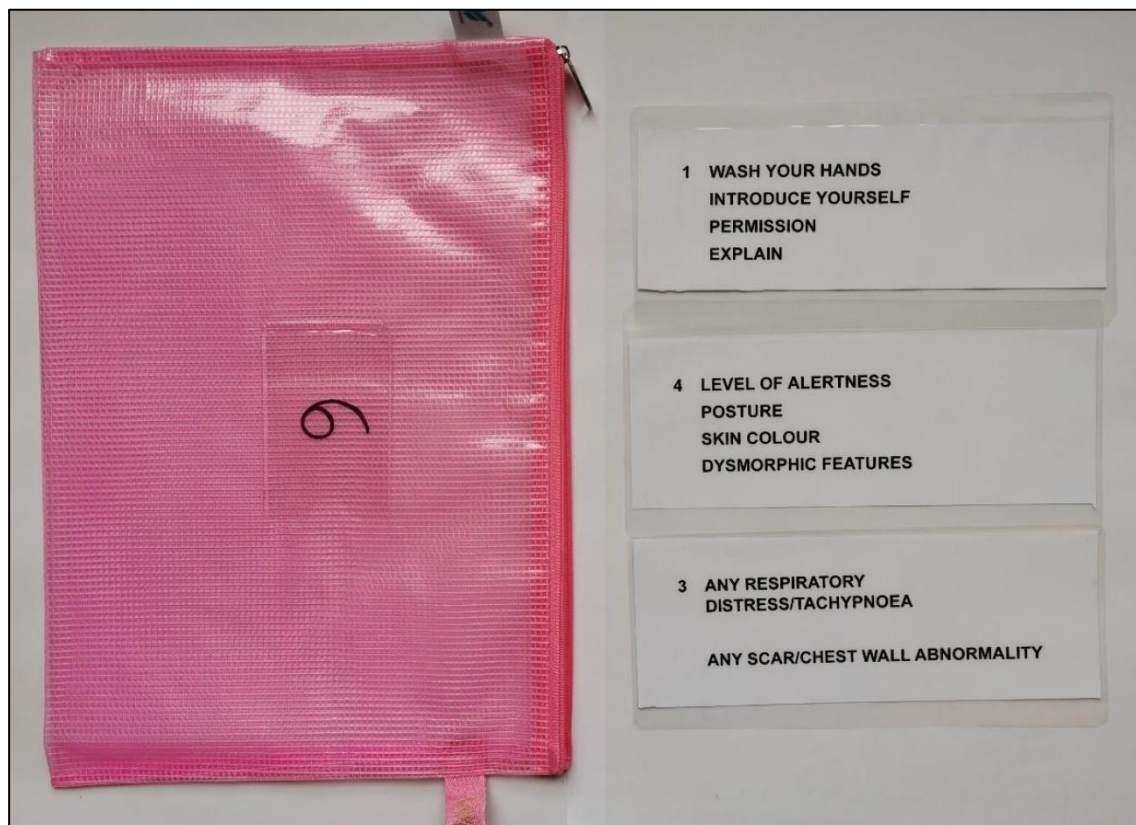


Figure 2.12. Contents of Box n.3, Folder n.6: cards with the appropriate steps to perform to approach the patient prior to starting the examination.

Figure 2.12. Content of Folder n. 6: one numbered card with the four introductory moments to perform before the newborn examination including washing the hands, introducing yourself, asking for permission to examine the baby and explaining your next steps and other two cards with moments specific to the cardiovascular examination of a newborn including the assessment of the level of alertness and the posture, skin colour, the presence of eventual dysmorphic features, presence of respiratory distress and of any scar or chest wall abnormality.

The code from this clue opens folder #7 that contains a picture of a lock with the caption:

"Closer inspection

** + * "*

To solve the puzzle, participants need to perform a closer inspection of the doll they found on the first box. The doll is covered with several numbers, some as intended misdirection and others placed in a position pertinent to the cardiovascular exam (Figure 2.13).



Figure 2.13. Contents of Box n.3, Folder n.7: card “closer inspection”. The doll found in Box n.1 has the clues to solve the clue in the card.

Figure 2.13. A card has the drawing of a small lock with two stars at the bottom separated by a plus, and the indication “closer inspection”. The doll was found in box one and specific numbers are printed on certain areas of it. These areas represent different clinical checks, for example pertinent to this clue, finding the number on the doll's lips represents the evaluation of the mucosae to check for central cyanosis and finding the number on the praecordium will align with the assessment of the presence of any active praecordium.

The sum of the numbers from the mouth and praecordium of the doll provides the code that unlocks the next folder.

With respect to effective cardiovascular examination of a newborn, the main dimensions to explore are signs of central cyanosis and the area of the praecordium. To solve the clues, players need to sum up the figures printed on the doll's mouth, representing the check of the mucosae to evaluate the presence of central cyanosis, with those on the praecordium area, to check if there is any active praecordium. The sum of the two numbers in these areas gives the code for the following folder that is focussed on auscultation.

The clues contained in folder #8 is divided into multiple steps. In the folder there are the following:

- A picture of a chest marked with the typical areas of auscultation of the heart: aortic, pulmonary, mitral and tricuspid valves. In the picture, each landmark is highlighted with a circle of a different colour (Figure 2.14).
- A sheet with four grids, one grid for each terminology found in the previous clue and marked by the corresponding colour. Under one specific letter per each word there is a small symbol (Figure 2.14).
- A Caesar cipher (Figure 2.14): a substitution cipher where each letter in the unencrypted text (plaintext) is replaced by a letter a fixed number of positions up or down the alphabet. For example, with a left shift of three, D becomes A, E becomes B, and so forth. This transformation can be visualised by aligning two alphabets: the cipher alphabet is a shifted version of the plain alphabet. In the cipher grid, symbols from the previous clue are matched with specific letters. To decrypt this cipher, it is necessary to write the letters found in the previous clue into the corresponding spaces in the cipher grid marked by symbols. This helps determine the correct alignment of the shifted alphabet. Once the grid is correctly filled, participants simply need to look up each letter of the message in the "cipher" line and write down the corresponding letter from the "plain" line (Luciano, 1987).
- Numbered cards with auscultatory cardiovascular findings (murmur, tachycardia, bradycardia, gallop, click, etc...) written on it.

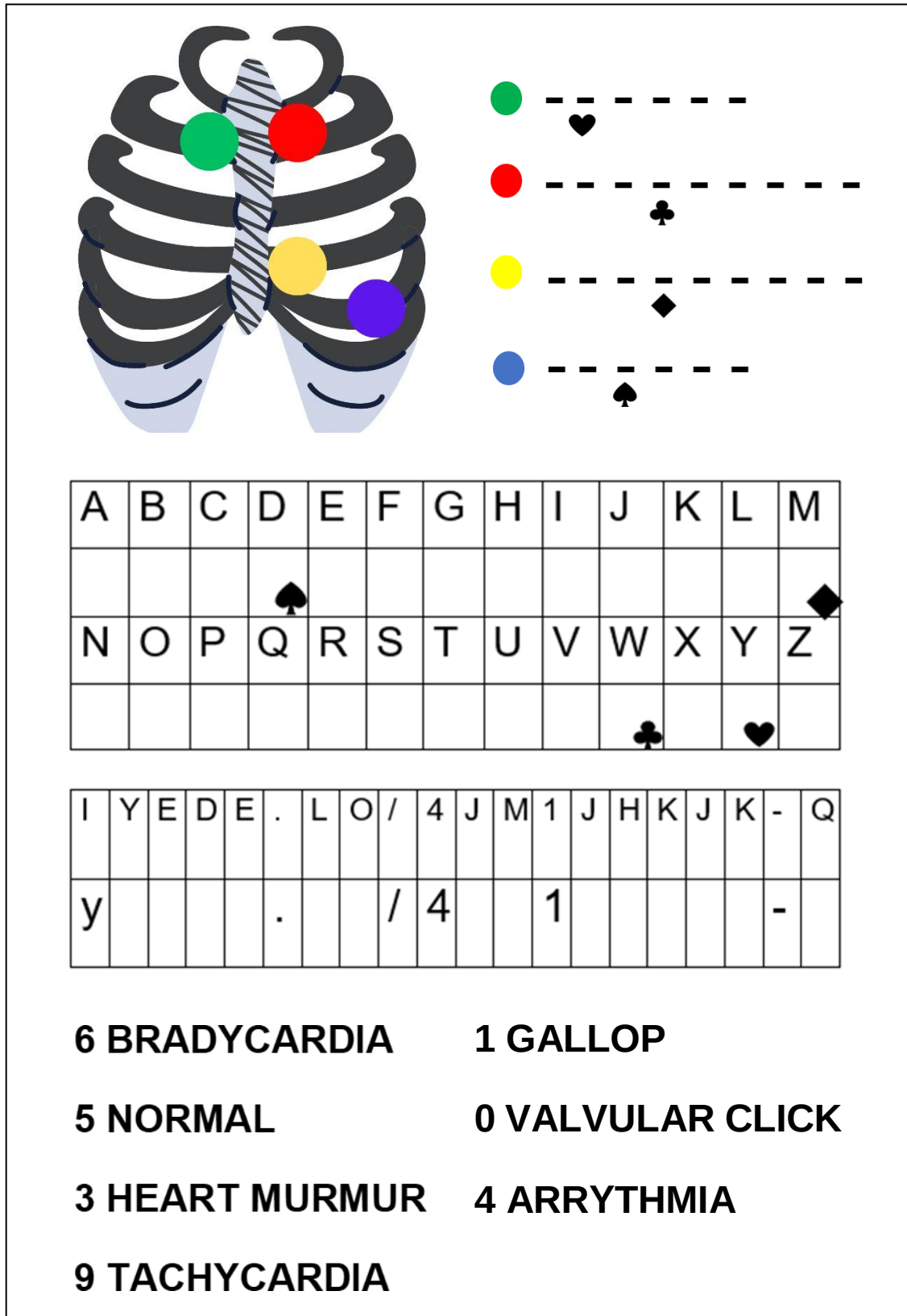


Figure 2.14. Contents of Box n.3, Folder n.8: Picture of chest, grid, Caesar cipher, and cards with auscultatory findings.

Figure 2.14. On top-left corner: a diagram of a human chest, with four distinct areas highlighted in different colours: the aortic, pulmonary, mitral, and tricuspid valves. Each area is each marked by a coloured circle: red, blue, green, and yellow. On the top right area: four grids are arranged, each with a heading in the colour matching the chest diagram (red for aortic, blue for pulmonary, green for mitral, yellow for tricuspid), and beneath one letter in each grid, there is a small symbol (a star, triangle, square, etc.). In the centre of the picture there is a cipher grid showing two rows of letters: one for the "cipher" alphabet and one for the "plain" alphabet. Some of the cipher grid's boxes are marked with the same symbols seen in the grids in the picture on the top right. Player must write the letters linked with the symbols into the cipher grid, positioning the letters next to their corresponding symbols and using these letters as a guide to fill the rest of the grid. The picture of the chest, coloured grids, Caesar cipher, and numbered cards all work together, allowing participants to decrypt the message and to find a link to an online video.

The decryption of the message brings the students to a link of an online video with three recorded audio traces of heart sounds: a normal variant, bradycardia and murmur (Figure 2.15).

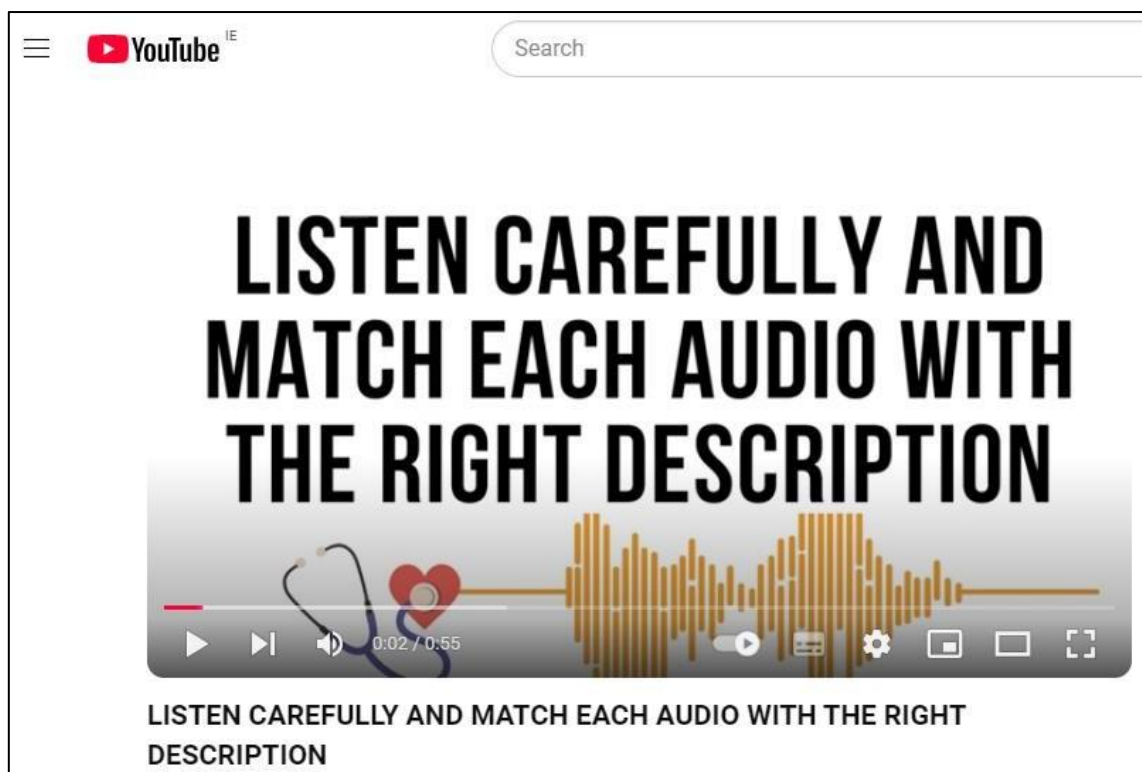


Figure 2.15. Screenshot of the online video with recorded audio traces of heart sounds.

Figure 2.15. This image shows the screenshot of the online video containing three auditory traces of different heart sounds finding (a normal heartbeat, a bradycardia and a heart murmur). Participants can now use the cards containing different auscultatory cardiovascular findings all numbered found on the Folder n.8 (as shown in the bottom of Figure 2.4) to link each auscultatory finding as recorded in the video to the correct terminology. The three numbers placed in the correct order form the code to open the next lock.

Participants are requested to organise the three cards according to the corresponding auditory trace. The numbers on the side of each card, if ordered rightly, will give the code to the next clue.

The last CVS folder is about palpation.

In folder #9, players will find a card similar to the one in folder #7 but with a different message:

“ Palpation

** * ** ** ***

ascending order

(if equal numbers apply, use the number once only)”

Students are called to recognise the areas of interest for what concerns the CVS palpation examination of the newborn, the same include femoral and brachial pulses, precordium, heaves and thrills and liver.

Then they will need to reorganise the numbers found on the doll in ascending order.

In case of bilateral findings such as brachial pulses or femoral pulses, or for those findings such as heaves and thrills where the palpation interests a wide area of the chest, the numbers on the dolls are the same (e.g. the number in the right femoral pulse area is the same as the one on the left femoral pulse). Following the instructions on the card, participants should use each number once only in case equals numbers apply.

2.6.5.4 Box n. 4 – The Ear Nose and Throat (ENT)

In Box No. 4, the hidden quizzes and puzzles are based on the head and neck assessment (ENT) as illustrated by the picture on the lid (figure 2.16).

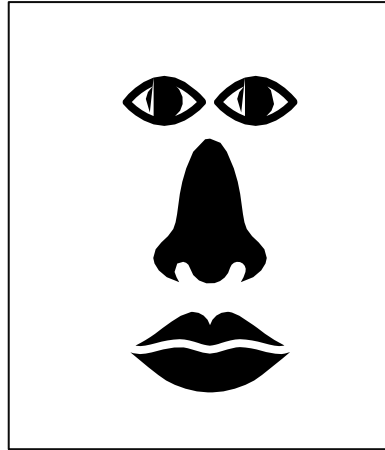


Figure 2.16. ENT image applied on the top of Box n.4.

Figure 2.11. Icon of eyes, nose and mouth applied on top of the box number three to symbolise the box subject: the ENT system.

The first folder of the box is folder #10. It is unlocked and includes the steps of a general inspection of the head and neck, as well as the initial generic steps of the newborn examination (Figure 2.17).

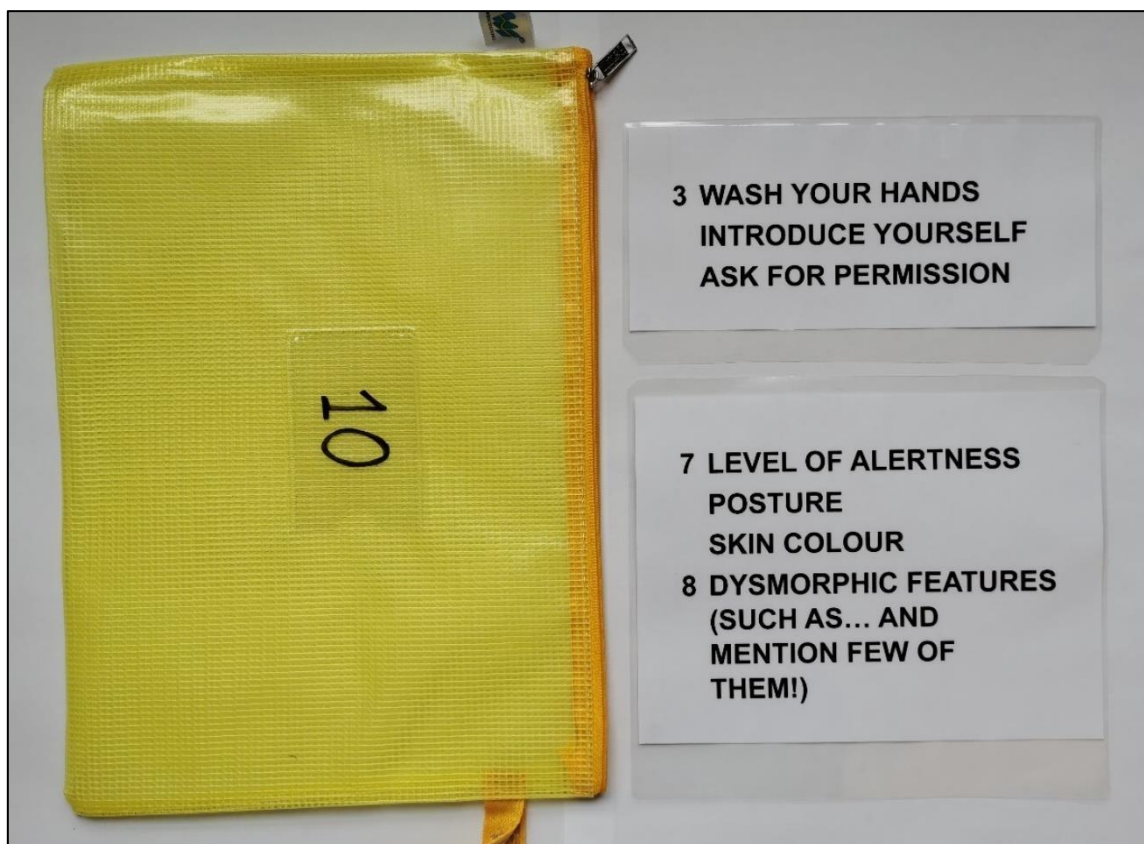


Figure 2.17. Contents of Box n.4, Folder n.10: introductory cards.

Figure 2.17. The picture shows folder number 2 content: two numbered cards, one with the four introductory moments to perform before the newborn examination such as washing the hands, introducing yourself, asking for permission to examine the baby and explaining your next steps and the other with moments specific to the ENT examination including the assessment of the level of alertness, posture and skin colour, and the presence of eventual dysmorphic features.

The code derived from solving this puzzle leads to folder #11 where students will find a measurement tape; no further information is added (2.18).



Figure 2.18. Contents of Box n.4, Folder n.11: measurement tape.

Figure 2.18: Folder 11 contains a measurement tape to perform a newborn OFC.

Once participants figure out that they again need to measure the baby OFC, the GM can comment on this, reminding the learners that measuring OFC, weight and length

and plotting them in an appropriate chart for age and gender should be done routinely with every baby. A second measurement of the OFC has been added as a memory aid for the students that they should actively perform the act of measuring the infant's head in both the CNS and ENT OSCE stations.

The measurement tape in this folder is slightly different from the previous one: the prop has a series of different numbers written on it, and when the students use it to measure the doll's OFC, it will provide the numbers needed to decrypt the next lock, placed on folder #12.

This time students will find a grid and an image (Figure 2.19): the image provided is a stylised drawing of the cranial sutures, including the metopic, coronal, sagittal, and lambdoid sutures, as well as the anterior and posterior fontanelles; it includes no nomenclature or caption on it.

Students should remember the appropriate terms and locate the correct terminology in a word search puzzle. Each name in the grid has a small number associated with it. Once the students find the keywords, they should add the numbers of each letter in the words together. The sum will form a three-digit number, which will allow them to access the next file.

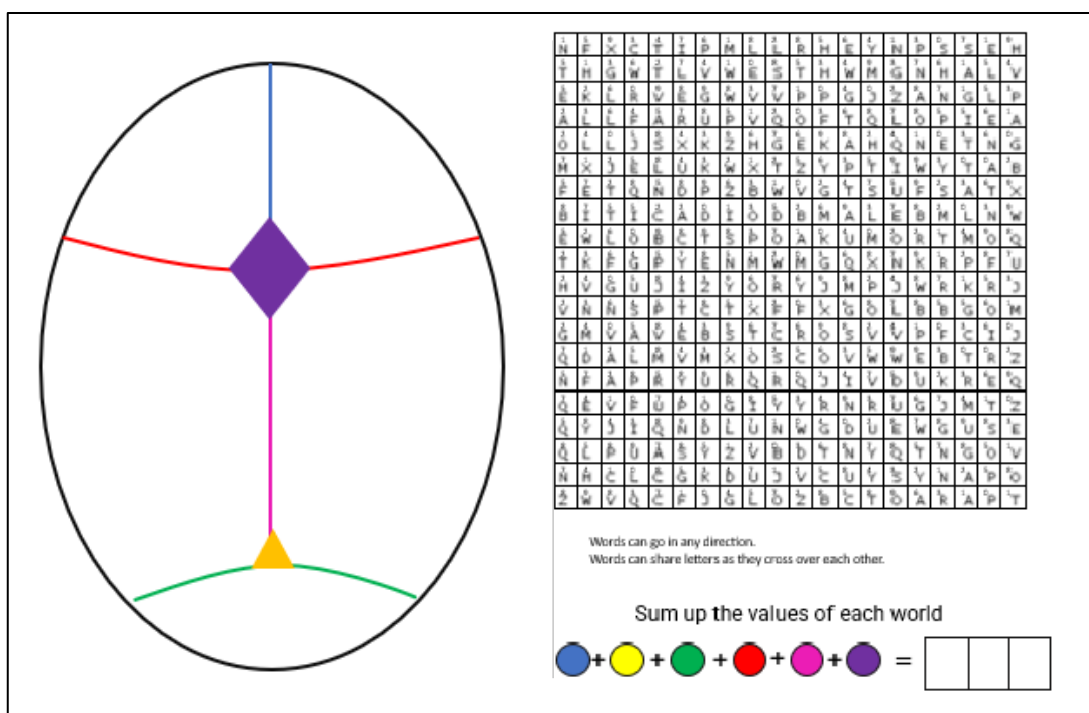


Figure 2.19. Contents of Box n.4, Folder n.12: picture of sutures, and grid.

Figure 2.19. The stylized drawing on the left illustrates the cranial sutures, including the metopic, coronal, sagittal, and lambdoid sutures, as well as the anterior and posterior fontanelles. The drawing includes no labels, encouraging students to recall and identify the

correct anatomical terms through the word search puzzle on the right. Each term in the grid corresponds to a number, and students must add the numbers of each letter in the terms to generate a three-digit code, which grants access to the next file in the activity.

Folder #13 contains numbered pictures of facial dysmorphic features such as epicanthic folds, hyper- and hypo-telorism, cystic hygroma, macrocephaly, sunset eyes and cleft lip (Figure 2.20).

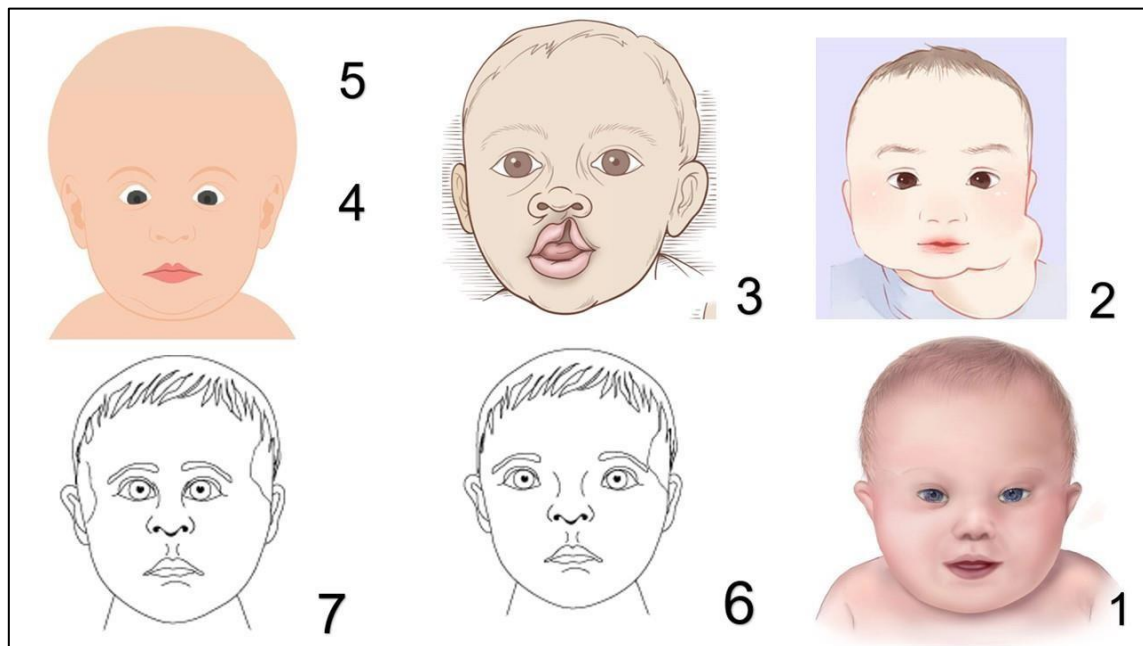


Figure 2.20. Contents of Box n.4, Folder n.13: images of dysmorphic features.

Figure 2.20. Pictures of facial dysmorphic features such as epicanthic folds, hyper- and hypo-telorism, cystic hygroma, macrocephaly, sunset eyes and cleft lip. Each picture is associated to a number.

In the folder there are also seven cards with one finding each and one letter of the alphabet on each of them (Table 1).

A laminated paper included with the clues contains the following equation:

$$[(A \times B / C - E) + D - F] \times G \times 4$$

To solve the puzzle, it is necessary to link each card with the right image and use the letters and associated numbers to solve the mathematical equation.

Table 1. Clues to solve the puzzle in folder n.13: each clinical finding as depicted in the numbered cards with the pictures of dysmorphic features must be associated with the correct terminology in order to obtain a numeric formula.

Cards with the names of the dysmorphic features and relative letter	Numbers in the pictures of the related dysmorphic features
A – Cleft lip	3
B – Epicanthic fold	1
C – Hypertelorism	6
D – Hypotelorism	7
E – Macrocephaly	5
F – Cystic hygroma	2
G – Sunset eyes	4

After substituting the letters with the associate numbers, the formula becomes a simple calculation:

$$[(3 \times 1) / (6 - 5) + 7 - 2] \times 4 \times 4$$

The result is the key to open the successive lock (folder #14) that reveals a picture of a newborn with a weakness of one of the upper limbs, that presents with absent shoulder abduction, external rotation, elbow flexion, and forearm supination (figure 2.21) (Abid, 2016) and a question stating:

“Bone or Neuro?”

Together with that image there are two files: one named Bone and the other Neuro. Inside, each contains four envelopes marked “USS, MRI, CT, Xray”, common shortenings for four typologies of imaging: ultrasound, magnetic resonance, computer tomography and x-ray.



Figure 2.21. Contents of Box n.4, Folder n.14: clinical picture and envelopes with possible imaging to assess the newborn accordingly.

Figure 2.21. Content of Folder 14 including a clinical picture of a newborn presenting with weakness in the left upper limb, characterized by absent shoulder abduction, external rotation, elbow flexion, and forearm supination. Accompanying the image is the question: "*Bone or Neuro?*" and four envelopes marked "USS, MRI, CT, X-ray," representing common imaging modalities ultrasound, magnetic resonance imaging, computed tomography, and x-ray used to further investigate the condition.

In a clinical scenario where a newborn exhibits the mentioned findings, a comprehensive physical examination of the musculoskeletal and neurological systems should be conducted, including both active and passive range of motion tests and an assessment of normal reflexes. This examination should also check for clavicular or humeral fractures, as these can mimic neonatal brachial plexus palsy by limiting the range of motion due to pain (Shah, 2021). In case of concerns an x-ray is usually the first-choice investigation.

This is the reason why all the envelopes (MRI, CT, and USS) are empty except for the one countersigned by the term "Xray" that contains the code to access to the next step. Students will need to choose the most appropriate imaging in order to progress, while the other options will be blank as inappropriate, causing only a delay in progressing.

This mimics a real-life scenario, where if a junior doctor orders an incorrect imaging, the Radiology team will usually flag the issue, suggesting the best option for the infant and causing a little time expenditure for the doctor that needs to reorder the most appropriate investigation.

The appropriate choice is reinforced also in the last clue for the ENT box: a little torch with a tag stating “x-ray” hidden in folder #15 (Figure 2.22).

The torch is a UV light and if used on the doll it will reveal on the shoulder of the doll the code written with a UV sensitive ink (and completely transparent under normal light) that will give access to Box n. 5.



Figure 2.22. Contents of Box n.4, Folder n.15: UV light and its use in the game.

This image features a small torch labelled “x-ray”. The torch emits UV light, which, when used on the doll, reveals a hidden code on the doll's shoulder written in UV-sensitive ink. The code is invisible under normal light but becomes visible under UV light, providing the key to access Box No. 5.

2.6.5.5 Box n. 5 – The Gastrointestinal system (GI)

Box n. 5 is the last box to explore and it is entirely focussed on the GI system. On the lid the image of a stomach leads the students to focus on this system (Figure 2.23).

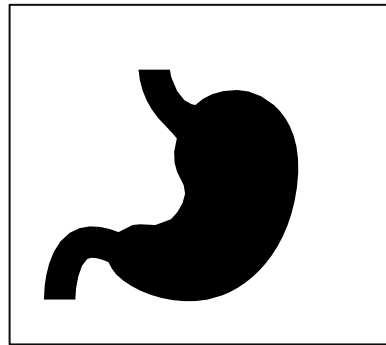


Figure 2.23. GI image applied on the top of Box n.5.

Figure 2.23. Stylised image of a stomach placed on top of box n.5 to introduce the students to the gastrointestinal system.

Mirroring the previous boxes, the first clue (folder #16) is in relation to the general inspection and the introductory steps to perform before examining each patient (Figure 2.24).

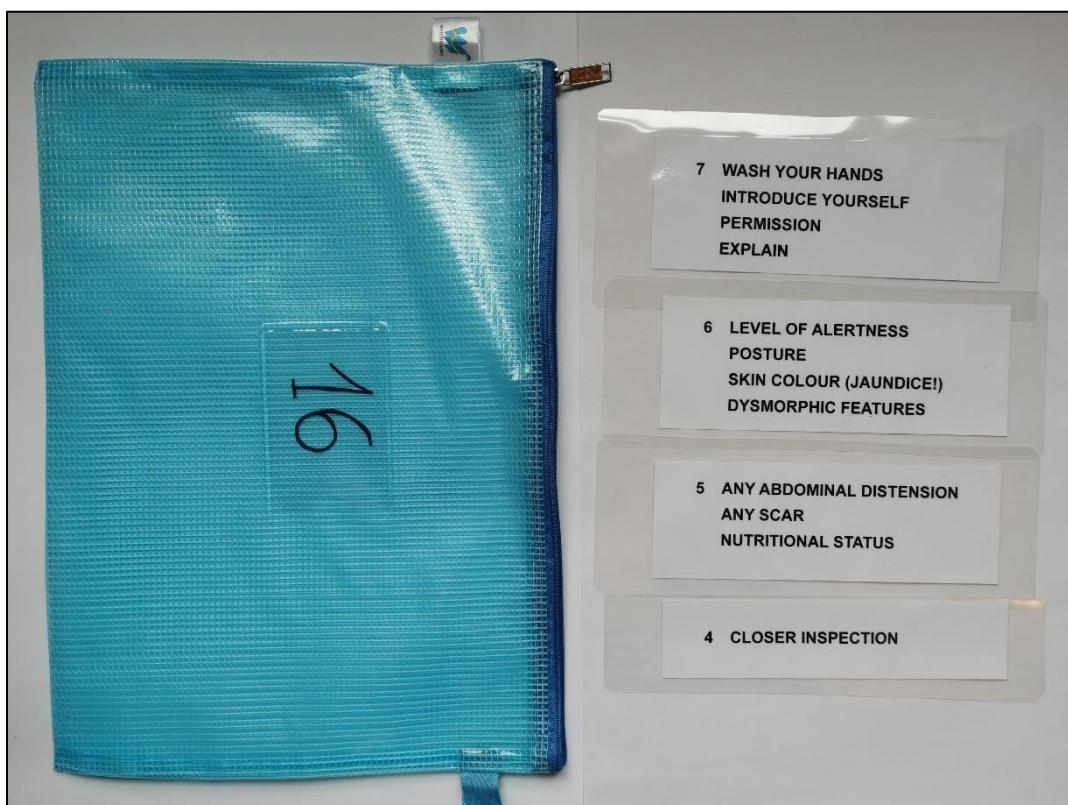


Figure 2.24. Contents of Box n.5, Folder n.16: introductory cards.

Figure 2.24. Folder Number 2 and its content. The folder contains four numbered cards. The first card outlines four essential steps to take before conducting a newborn examination, including handwashing, introducing yourself, seeking permission to examine the infant, and explaining the upcoming procedures. On the second card there is level of alertness, observation of the posture, skin colour, and any potential dysmorphic features. The third card includes abdominal distension, scars and nutritional status. These two are related to the GI system examination. On the fourth card the words “closer inspection” invite the students to the next step of the clinical examination..

It is followed by folder #17 that contains a jigsaw, a grid full of numbers and a secret message (Figure 2.25). The secret message is the key to progress in this part of the game.

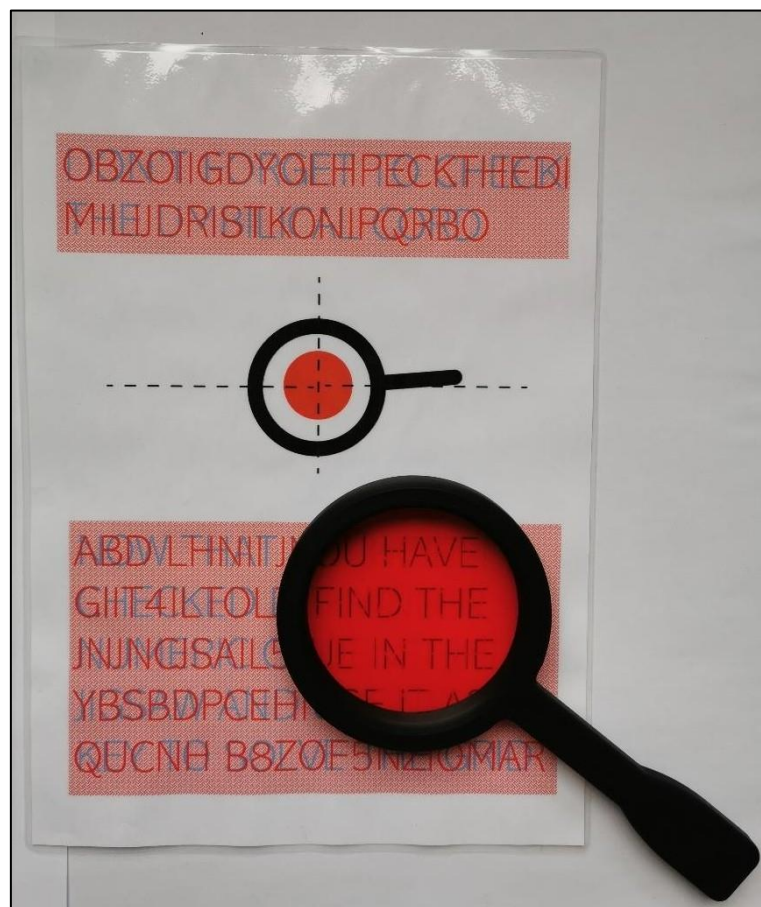


Figure 2.25. Contents of Box n.5, Folder n.17: secret message.

Figure 2.2. Encrypted message and its solution: to decode the hidden sentence, participants must overlay the magenta magnifying lens discovered in the first box to the laminated sheet. When the acetate is placed over the doodle, the hidden message will be revealed, guiding them further in the activity.

The message looks like an intricate doodle printed in red colour with some hint of blue paint. To unlock the message, participants must use the transparent magenta acetate

sheet they found in the very first box: overlapping the sheet on the message will reveal the following message:

“Don’t forget to check the umbilical cord. Now that you have checked it, find the numeric clue in the jigsaw and use it as a code to solve the grid”.

The clue first prompts the players to inspect the doll’s umbilicus, where they find a small smiley face. Dolls and mannequins typically lack an umbilical stump, and often at the OSCE GI examination station students forget to mention that they would check for signs of omphalitis or abnormalities around the cord stump. Encouraging them to actively look for the umbilicus aims to remind them to check it (and mention the action they are performing) during the formal exam.

Following on from the riddle, participants are encouraged to solve quickly the puzzle that will reveal a picture of the abdominal organs (Figure 2.26).

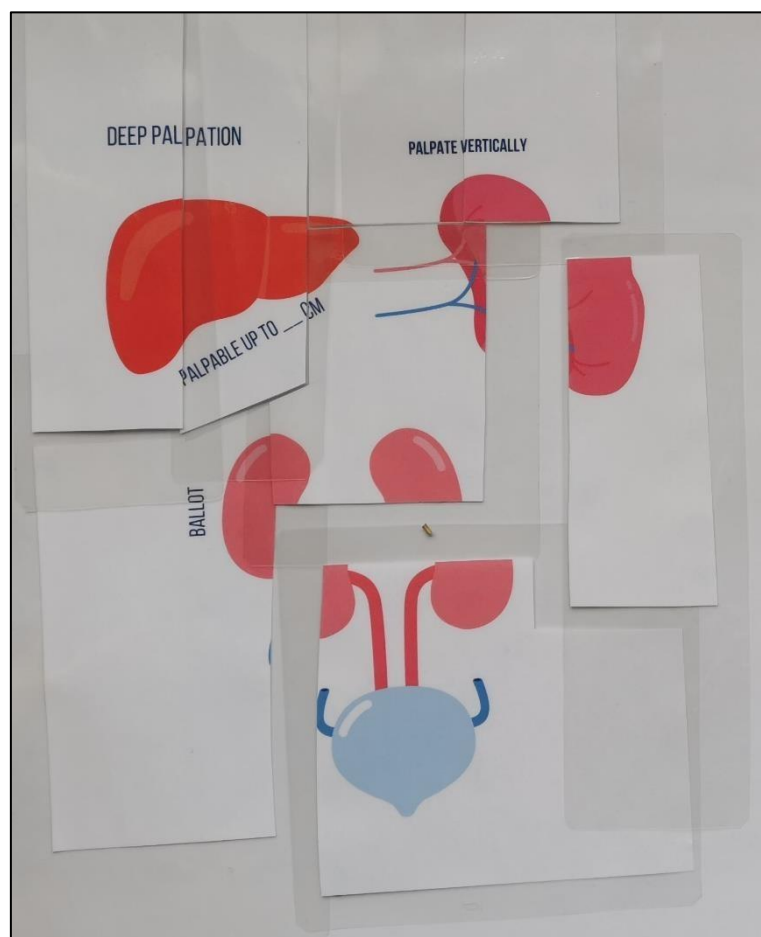


Figure 2.26. Contents of Box n.5, Folder n.17: jigsaw puzzle.

Figure 2.26. Jigsaw puzzle of abdominal organs with numeric clue that leads to the code to decrypt a numeric grid found in the same folder.

In the picture, under the liver it states

“Palpable up to _ _ _”

The numerical solution of this clue indicates the normal limit in centimetres of the hepatomegaly, and the correct answer is the number two.

The final step of this intricate part involves a grid filled with numbers (Figure 2.27).

0	3	5	9	8	4	6	3	5	7	9	8	5	4	1	0	0	8	5	0
5	8	2	2	9	8	5	4	1	0	0	8	5	9	6	8	7	4	1	3
6	2	2	2	8	5	0	8	5	0	8	5	0	8	5	0	8	5	0	8
2	2	2	2	4	1	3	4	1	3	4	1	3	4	1	3	4	1	3	4
1	7	2	2	0	9	0	0	9	0	0	9	0	0	9	0	0	9	0	0
0	8	2	2	8	5	0	8	5	0	8	5	0	8	5	0	8	5	0	8
7	4	2	2	3	5	7	3	5	7	3	5	7	3	5	7	3	5	7	3
8	5	2	2	4	1	0	4	1	0	4	1	0	4	1	0	4	1	0	4
4	1	2	2	0	8	2	2	2	2	3	0	8	2	2	2	2	2	2	0
0	9	2	2	7	4	2	2	2	2	2	7	4	2	2	2	2	2	2	7
0	8	2	2	8	0	8	5	0	2	2	8	5	2	2	8	5	0	8	5
0	2	2	2	2	7	4	1	7	2	2	4	1	2	2	4	1	3	4	1
7	0	1	1	0	8	5	0	8	2	2	0	9	2	2	0	9	0	0	9
8	7	0	8	5	0	0	7	2	2	9	0	8	2	2	8	5	0	8	5
0	8	5	0	0	8	7	2	2	2	0	7	4	2	2	3	5	7	3	5
7	4	1	3	7	4	8	6	2	2	1	8	5	2	2	4	1	0	4	1
5	0	9	0	5	0	4	5	6	2	2	4	1	0	2	2	2	9	6	5
0	8	5	0	0	8	0	3	6	2	2	0	9	7	9	8	2	2	8	3
7	4	1	3	7	4	0	5	9	2	2	8	5	0	8	5	0	2	2	1
5	0	9	0	5	0	2	2	2	2	2	4	1	3	4	1	3	2	2	4
0	8	0	8	5	0	2	2	2	2	1	0	9	0	0	9	0	2	2	5
7	4	7	4	1	3	0	8	5	0	8	8	5	0	8	5	0	2	2	7
8	5	5	0	9	0	7	4	1	7	4	3	5	7	3	5	7	2	2	0
4	1	0	8	5	0	8	5	0	8	5	4	1	0	4	1	0	2	2	6
0	9	7	4	1	3	4	1	3	4	1	3	4	2	2	2	2	2	0	9
0	8	5	0	9	0	0	9	0	0	9	0	0	3	2	2	2	3	7	9
7	4	0	8	5	0	0	8	5	8	5	0	8	5	9	8	7	4	8	0
8	4	6	3	5	7	8	4	6	3	5	7	3	4	6	3	5	7	8	4
9	8	5	4	1	0	9	8	5	4	1	0	4	8	5	4	1	0	9	8
8	4	6	3	5	7	8	4	6	3	5	7	3	4	6	3	5	7	8	5
9	8	5	4	1	0	9	8	5	4	1	0	9	8	5	4	1	0	9	8
8	4	6	3	5	7	8	4	6	3	5	7	8	4	6	3	5	7	8	4

Figure 2.27. Contents of Box n.5, Folder n.17: numeric grid.

Figure 2.27. Numeric grid contained in Folder n. 17. To solve this activity, students need to find first the numeric clue found in the jigsaw puzzle (Figure 2.26). They then need to colour all the numbers in the grid to discover the code for the next activity.

The number obtained from the previous activity serves as the key to solving this puzzle: by shading in all the number twos within the grid, three distinct numeric figures will emerge. The three numbers are, of course, the code for the last puzzle (folder #18).

In this folder is a cardboard tablet with, on top, a simulation of three scrotums made by fabric (Figure 2.18).



Figure 2.28. Content of Box n.5, Folder 18: palpation tablet.

Figure 2.28. This image features a cardboard tablet designed to aid in palpation practice. Each fabric scrotum contains either cubic, spheric or cylindrical shapes, representing the testes. Underneath two of the scrotums (top right picture) the presence of a small star indicates the — anus, highlighting the critical importance of this check during a newborn examination.

The first scrotum contains a cubic shape bilaterally, to mimic the testes, the second has a unilateral cylindrical shape and the last one a unilateral spheric shape. The only way to discover the shapes and their presence is through palpation of the prop.

In addition, underneath two of the three scrotums there is a little star to indicate the presence (or not) of the anus, and this remarks how important it is to check its presence during a baby check. An imperforate anus is a medical emergency, and it should be dealt with urgently.

Alongside the tablet, are a series of numbered cards, each illustrated with a different picture (Figure 2.28).

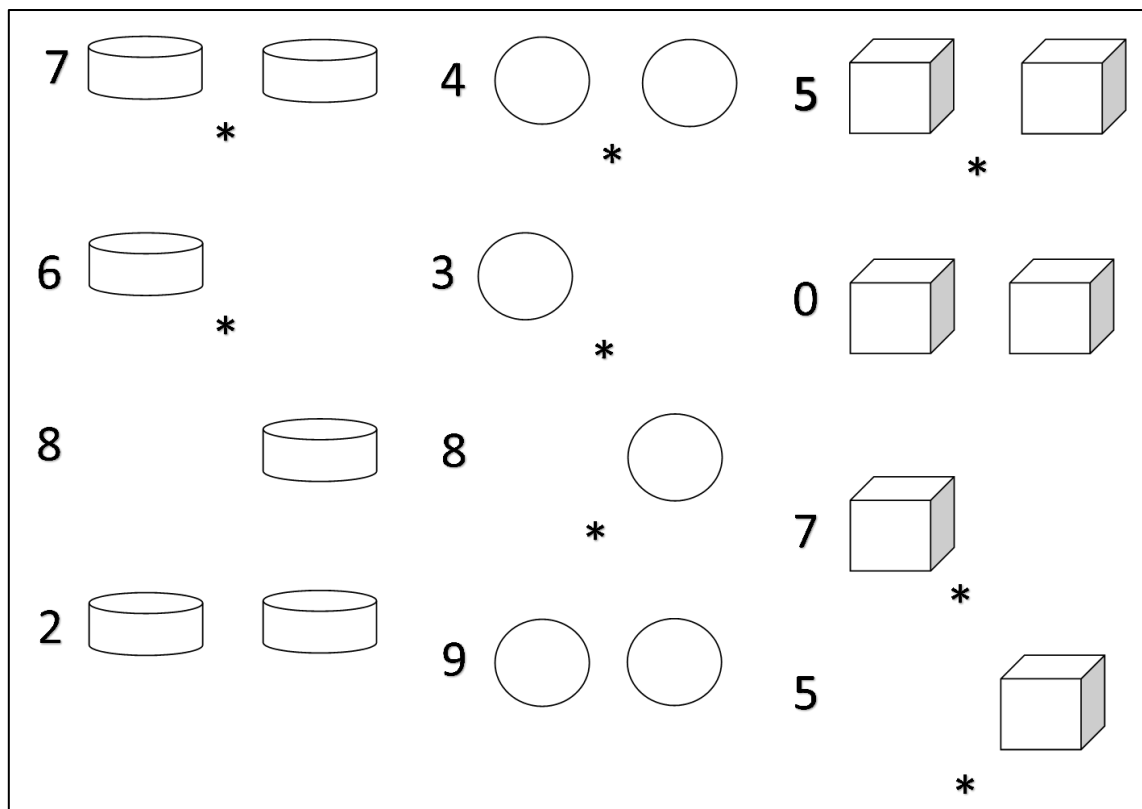


Figure 2.29. Content of Box n.5, Folder 18: illustrated cards.

Figure 2.29. series of numbered cards, each illustrating different configurations of shapes, cubes, cylinders, and spheres with or without stars. These images serve as a two-dimensional representation of the tactile findings from the simulation. Participants must identify the correct illustrations, and the numbers on the cards will give the code to unlock the final part of the game.

Each card gives a possible sequence of either cubes, cylinders or spheres (there may be one on the right of the card and none on the left, one on the left of the card and none on the right, or two printed on the card) with or without a little star under the shapes. The images are a bi-dimensional representation of the tactile findings of the testes and of the presence of the anus; once participants will find the correct illustrations, the numbers on them will give the code to the last part of the game.

Folder #19, the last one of the games, contains a QR code that will link participants to a video showing a baby in a cot carried at high speed through the corridors of the hospital. After a couple of turns in the Rotunda wards, the baby finally arrives in their own room.

The ER is over, and this means the team successfully completed the game!

2.6.6 End-of-activity debrief.

After the ER activity, a debrief was facilitated through an After-Action Review (AAR) as a structured review process which allows groups of learners to reflect on a learning event and identify opportunities for development (Keiser, 2021). This tool focuses on four questions which seek to explore learners' expectations of what would happen, what happened, why was there a difference between the two, and what can be learned from the event (Health Service Executive, 2020).

By exploring these questions, participants could analyse both the successes and challenges of the event, understand the reasons behind them, and enable them to make informed decisions about changes or improvements needed to improve performance.

After the ER, the time dedicated to the debrief was between 15-20 minutes and the AAR was led by the GM. Data were collected in written notes through thematic keywords arising from the answers of the participants to the following questions:

1. Review of the initial expectations

What were the team's expectations going into the ER?

2. Actual events that happened during the ER

How did the team perform on the puzzles?

Which ones were solved quickly, and which ones posed a challenge?

Were there any unexpected challenges or surprises?

How did the team's communication and collaboration play out in reality?

Did everyone contribute as expected?

3. Analyse the gaps between expectations and reality

If the team struggled with certain puzzles, why was that? Was it due to a lack of knowledge, poor communication, or something else?

How did the pressure of time affect decision-making and problem-solving?

4. Identify key takeaways and lessons learned that can be applied in the future

What strategies or approaches worked well and should be repeated in the setting of the exam?

What specific improvements can be made to enhance personal performance, teamwork, communication, or problem-solving?

The decision to take notes during debrief sessions was influenced by several practical, ethical, and methodological considerations. While digital recordings would have allowed for full reviewability, enabling multiple revisions of the material to extract additional insights, I felt this approach could have acted as a barrier to participation. Some participants might have felt uncomfortable being recorded, which could lead to hesitancy due to privacy concerns and potentially influence their responses, limiting candid feedback.

From an ethical perspective, recording conversations necessitates secure storage, controlled access to the data, and compliance with regulations such as the General Data Protection Regulation (GDPR) 2016/679, which imposes additional requirements for handling and storing recordings.

From a practical standpoint, note-taking provides an immediate way to summarize key points and synthesize information in real time, whereas reviewing lengthy recordings can be time-consuming.

Therefore, despite the benefits of digital recordings in terms of accuracy and detail, the decision to take notes was guided by practical constraints, ethical responsibilities, and the need to foster a more open and comfortable environment for participants.

2.7 Data collection

As highlighted above the students that took part in this study were arranged into two groups. The first group took part in the ER (test group), the others (control group) took part in a period of self-directed learning of a comparable duration. To explore the experiences of the test group in comparison to the control group quantitative data derived from OSCE and MCQ assessments and from an ER perception survey were used.

For this study, both educators and OSCE examiners were blinded to the survey's measured outcomes.

2.7.1 OSCE and MCQ assessments

As part of their assessment, at the end of their attendance in the Maternity hospital, every medical student must demonstrate that they can master a newborn clinical examination and be able to manage common neonatal medical issues in a safe and appropriate way.

At the end of each rotation is a single seven-minute mock OSCE station focused on a common neonatal vignette. This mock OSCE is mandatory for all the students with the aim to assess their clinical skills, attitudes, problem-solving abilities, and their application of knowledge within simulated environments. Lecturers, blind to students' participation in the ER, supervise this practice and assess their progress.

A mock MCQ exam is distributed as further preparation to their final Paediatric exam (Appendix 6).

The MCQ assessment is administered in Moodle (GNU General Public License): the virtual learning environment used for the course at RCSI. Moodle is a free open-source software package designed on the basis of pedagogical principles, to help educators create effective online learning communities.

Questions here assessed baseline knowledge of neonatal clinical presentations, issues and the first steps of their management.

Performance data from the mock assessments of the participants to the study (both GER and GRT) was collected in a pseudo-anonymised fashion and analysed for the purpose of the research project.

The analyses of data from mock OSCE, and the questionnaire provided information on the impact of educational ERs as a novel educational tool on the OSCE performance.

Performance data from mock MCQs in preparation for the final Paediatric exam were analysed to assess the impact of using an ER to facilitate effective long-term learning of clinical medical students.

2.7.2 Escape room perception survey

In addition, participants in the case arm of the study (GER) were invited to complete a 12-question survey previously validated with cohorts of medical students and adapted from Eukel et al (Eukel, 2017), to measure overall perceptions of the gaming activity

including support for their own learning, nature of learning activity and teamwork. The survey explored their reflection upon their different learning experiences and aimed to evaluate whether ERs could facilitate the acquisition of knowledge, leadership, and teamwork competencies in undergraduate healthcare profession students. Items 9 and 10 of the survey were reverse scored aiming to reduce eventual response bias. The perception scale was a five-point Likert scale ranging from “1= strongly disagree” to “5 = strongly agree”.

2.8 Data Analyses

For this study dependent variables were scores of students obtained in the mock OSCE and MCQs performance.

Independent variables were gender, quality and setting of the mock OSCE stations and time allowed for each station.

Missing data were not analysed or estimated.

A p-value < 0.05 was considered to be significant.

All analyses were performed using Stata Version 17.0 (StataCorp, College Station, TX, USA). Participants' OSCE station scores OSCE performances were analysed and compared with Mann Whitney U test.

The data were found not to be normally distributed on the Shapiro-Wilks test. A Mann-Whitney U test was performed to compare the continuous variables of OSCE scores between the GER (cases) and the GRT (controls).

For what concerns data relative to the MCQs marks, a Shapiro-Wilks test was used to assess the normality of the resulting data that were found to be normally distributed. A Student's t-test was used to determine if there was a significant difference between the scores on the GRT group results and the GER results.

Quantitative data comprised a perception exit survey based on 12 questions to measure overall perceptions of the gaming activity including support for their own learning, nature of learning activity and team learning. Each answer to the questionnaire was rated by students on a five-point Likert scale and the responses were measured on a scale ranging from '1 = strongly disagree' to '5 = strongly agree', with items 9 and 10 of the survey reverse-scored.

All data were collected pseudo-anonymously.

2.9 Summary of the Chapter

Medical ERs offer a dynamic and immersive method of medical education, combining entertainment with learning. This approach may enhance retention, teamwork, critical thinking, and application of knowledge, providing a valuable supplement to more traditional teaching methods in medical education.

For this study, I designed and developed a physical ER where teams of players had one hour of time to solve a chain of neonatal content-specific challenges.

As detailed explained in Chapter 2.5, quizzes and clues were formulated to test and challenge multiple intelligences, and to make sure all the students were provided with a learning environment that could accommodate their diverse needs, abilities, and learning preferences.

The design of this educational ER required careful consideration of medical authentic settings, and engaging puzzles. By incorporating these elements, I intended to create a dynamic and immersive learning environment that could enhance critical thinking, teamwork, and practical application of medical knowledge.

Clues alignment with the learning objectives of the curriculum had a central role in the design of this ER.

Participants were voluntarily recruited between all the medicine undergraduate training students attending their mandatory neonatal rotation in the Rotunda Hospital.

During the game sessions I covered the role of GM to allow a smooth flow, and a good support to the students.

An AAR was conducted to appraise the experience and with the students, collecting their reflections upon their participation.

At the end of the educational activity, students were asked to complete a validated survey based on a five-point Likert scale that aims to gather information on participants' learning experience during their ER experience.

In this mixed methods study, I analysed quantitative data from participants' mock OSCE and mock MCQs performances. Qualitative analyses included a perception exit survey based on a five-point Likert scale and students' perceptions in the format of a structured debrief based on HSE AAR structure.

3. RESULTS

3.1 Chapter Overview

In this chapter, the results of the thesis are presented, starting with a summary of the key findings, providing an overview of the study's results. The chapter starts with a thorough analysis of the data, exploring the various methods used to interpret the collected information, first the performance outcomes from the OSCE, next the results of MCQs, providing insights into participants' knowledge acquisition. Then findings from the perception exit survey are presented, revealing participants' views and experiences related to the ER activity. Finally, qualitative data from the debriefing sessions is analysed, offering a deeper understanding of the participants' reflections and the educational impact of the intervention.

3.2 Results:

In total, over 262 students attending the Neonatal rotation in the Rotunda Hospital, and 143 students (55%) participated in this study.

Among this cohort, one participant did not attend the mock OSCE station and two did not give consent to use their personal data and were therefore excluded from the study.

The GER group included a total of 73 participants with 42 female (57.5%) and 31 male (42.5%). The GRT group counted 69 participant: 30 female (43.5%) and 39 male (56.5%).

All the students were 4th year medical students.

3.2.1 Results of OSCE performances

The test revealed no significant difference between the two groups, $U = 2149$, with a total of 73 GER and 67 GRT; p -value was calculated as 0.908.

The results suggest that there is no statistical difference between OSCE scores of GER and GRT with a minimal effect size ($r = -0.121$) (Table 2).

Table 2: Mann-Whitney U test

	U	df	p	Rank-Biserial Correlation	SE Rank-Biserial Correlation
OSCE results	2149.000		0.908	-0.121	0.098
<i>Note.</i> Effect size is given by the rank biserial correlation.					
<i>Note.</i> the alternative hypothesis specifies that group case is greater than group control.					

3.2.1 Results of MCQs marks

The learning outcomes related to cognitive domain were evaluated via sixteen item MCQ, for which each student could achieve an overall maximum score of 16, with one mark for a correct answer, and no negative marking for a wrong answer. Completion of the mock questions was entirely facultative and a total of 100 students answered the MCQs. In this cohort, 38 students were included in the study as they initially gave consent to participate in this research project: 17 belong to the GRT group and 21 to the GER group.

No significant difference in MCQs results ($t = 0,544$ $df = 36$, $p\text{-value} = 0.59$) was detected between the intervention and non-intervention groups suggesting that there is no statistical difference between MCQs marks of GER and GRT (Table 3).

Table 3: Student's t-test.

<i>Independent Samples T-Test</i>			
	t	df	p
MCQs results	0.544	36	0.590

3.2.2 Results of Perception Exit Survey

Median and relative interquartile range (IQR) was calculated for each question.

Table 4: Exit survey results. Median (IQR)

	Median (IQR)	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)	n/a
1. The escape room encouraged me to think about material in a new way.	5 (1)	0	0	0	28 (38.4%)	45 (61.6%)	
2. I would recommend this activity to other students.	5 (0)	0	0	2 (2.7%)	15 (20.5%)	56 (76.7%)	
3. I learned from my peers during the neonatal escape room.	5 (1)	0	1 (1.4%)	4 (5.5%)	22 (30.1%)	46 (63%)	
4. The escape room was an effective way to review the topic of neonatology.	5 (1)	0	1 (1.4%)	2 (2.7%)	28 (38.4%)	42 (57.5%)	
5. The escape room was an effective way to learn new information related to neonates.	4 (1)	0	1 (1.4%)	8 (11%)	26 (35.6%)	38 (52%)	
6. I learn better in a game format than in a lecture.	4 (1)	1 (1.4%)	4 (5.5%)	11 (15%)	24 (32.9%)	33 (45.2%)	
7. The escape room was an effective way to around managing a newborn check.	5 (1)	1 (1.4%)	1 (1.4%)	1 (1.4%)	26 (35.6%)	43 (58.9%)	1
8. I feel I was able to engage with my teammates to learn new material.	5 (1)	0	1 (1.4%)	5 (6.8%)	28 (38.4%)	39 (53.4%)	
9. It was difficult for me to focus on learning because I was feeling stressed or overwhelmed.	2 (1)	30 (41.1%)	30 (41.1%)	4 (5.5%)	7 (9.6%)	2 (2.7%)	
10. The non-educational portions (e.g., puzzles, etc.) distracted me from learning about newborn check.	2 (1.25)	18 (24.6%)	32 (43.8%)	14 (19.2%)	5 (6.8%)	3 (4.1%)	1
11. I prefer assembling information from a variety of sources when learning new material.	4 (1)	0	4 (5.5%)	12 (16.4%)	30 (41.1%)	27 (37%)	
12. In general, I enjoy playing games (video games, board games, social media games, etc.).	5 (1)	2 (2.7%)	3 (4.1%)	7 (9.6%)	20 (27.4%)	41 (56.2%)	

The table (Table 4) shows that all participants submitted responses.

The majority “agreed” or “strongly agreed” that the activity encouraged them to think about material in a new way, and 97% of the cohort “agreed” or “strongly agreed” that they would recommend the ER to other students.

Many participants felt that they learned from peer colleagues during the neonatal ER (n=68, 93.1%), and almost 92% of participants felt they were able to engage with their teammates to learn new material.

Additionally, the majority of participants agreed or strongly agreed that ER is an effective tool for enhancing their learning and reviewing the topic of neonatology (n = 70, 95.9%), acquiring new information about neonates (n = 64, 88.9%), and assisting with their understanding of managing a newborn check (n = 69, 94.5%).

Participants that usually enjoyed playing games including on-line and in person games and social media games, were 83%, constituting the majority of the participants.

A large proportion of participants disagreed or strongly disagreed that it was difficult to focus on learning due to feeling stressed or overwhelmed during the ER and that the non-educational portions (e.g., puzzles, etc.) distracted them from learning about newborn check (respectively n=60, 82.2% and n=50, 68.5%)

However, it should be noted that a small portion of the participants felt the non-educational portions (e.g., puzzles, etc.) of the activity acted as distraction from learning about newborn check (n=8, 10.9%).

3.3 Additional Information and Insights

3.3.1 Results of the Debriefing

After the students' participation in the ER activity, I performed a structured a debrief with the intent of encouraging learners to reflect critically on their learning experiences using an open discussion format guided by the AAR modality. Such qualitative debriefs are highlighted as key ways to explore and improve novel game-based learning activities (Van Den Hoogen, 2016).

Here the debrief, lasting approximately 15-20 minutes, was facilitated by the GM, and student perception data were collected through written notes, with key themes

organised according to the AAR structures.

The debriefing data was organised into four sections:

1. Review of Initial Expectations:

Participants were asked to reflect on their initial expectations going into the ER. The consensus was that the activity was "way more fun than expected," which suggests that the experience exceeded their expectations in terms of engagement and enjoyment. This positive sentiment set the tone for the subsequent discussion on performance and learning outcomes.

2. Actual Events During the ER

The debriefing then explored the actual events that took place during the ER. The majority of participants expressed satisfaction with their overall performance, highlighting effective communication, mutual respect, and strong teamwork as critical factors in their success. Specifically, participants emphasised the effectiveness of the reminder regarding the umbilical cord and the initial steps of hygiene and introduction to the patient.

A particular preference for quizzes involving hands-on interaction with props was noted. For instance, students expressed their preferences on activities such as finding the number on a doll's clavicle using UV light, palpating the prop testicles content and decoding a code through a scarf test on a translucent silhouette. These quizzes were cited as especially engaging and educational as they were perceived as not only enjoyable but also as reinforcing practical clinical skills.

3. Analysis of Gaps Between Expectations and Reality

When analysing the gaps between expectations and the actual experience, participants identified knowledge gaps during specific parts of the game. They recognised that these gaps impacted their ability to solve certain puzzles, reinforcing the value of the ER in highlighting areas needing further study. Despite these challenges, students appreciated the opportunity to identify and address their knowledge deficits.

Additionally, four groups of students mentioned that the time restrictions and time pressure in the ER were valuable in preparing them for the OSCE examination. This time-sensitive environment mirrored the conditions they would face in the exam, helping them develop decision-making and problem-solving skills under pressure.

4. Key Takeaways and Lessons Learned

The debrief concluded with a discussion on key takeaways and lessons learned. Participants universally agreed that the ER was effective in providing a comprehensive clinical picture of what is expected during a baby check. They felt that the activity successfully connected previously gathered information and reinforced their knowledge in a practical, memorable way.

Furthermore, participants reflected on the importance of repetition in mastering clinical skills. The iterative nature of the ER's challenges allowed them to practise and refine their techniques, leading to improved performance. They emphasised the value of continuing to practise these skills to enhance personal performance, teamwork, communication, and problem-solving abilities.

3.3.2 Course Reflection after the Study

An unanticipated source of information about the ER experience came from the mandatory written student reflection on any aspect of their paediatric experience (Appendix 1).

A key piece of feedback that a student highlighted in their essay was that this educational ER should be integrated into more learning experiences because it fostered genuine problem solving and encouraged them to think beyond textbook knowledge.

As a qualitative outcome of the activity, the student remarked that this educational ER required them to apply both theoretical knowledge and practical skills in a way that traditional learning rarely facilitated, simultaneously forcing them to practise skills to aid the collective working towards a common goal.

The student described how each group member contributed their unique skills toward a shared goal, reinforcing the ER's effectiveness in developing soft skills such as communication, critical thinking, problem solving and adaptability; attributes widely recognized as essential in medical education (Morrell, 2019; Carvalho et al., 2015; Guillén-Nieto, 2011; Šimić et al., 2015). They also reflected on how the ER prompted a shift in perspective, encouraging a more holistic approach to patient care by recognizing the complexity of real-world medical scenarios as it “forced them [to take] a more complex view outside of the textbook information, similarly to how each patient

and situation is very different from the last and it is important to analyze each situation as a complex individual or situation”.

The student’s reflection also included how the ER was “incredible for a kinaesthetic learner like me, and I felt so genuinely focused and engaged” and referred that “every member of my group despite their typical ‘learning style’ coming alive through this activity” as it provided an immersive, hands-on learning environment. This underscores the ER’s potential to cater to diverse learning preferences while reinforcing key competencies.

As it was felt that this insight would be valuable for refining our ER design and maximising its potential in future iterations, a decision was made to include it as an appendix in this thesis upon approval from the student that wrote it (Appendix 1).

Such reflections provide deep insights into the participant's experiences, emotions, and perceptions, which are often not captured by quantitative measures like test scores.

This data also suggests that the students’ reflective essays may have held fruitful details about the student voice and viewed retrospectively, may have been a valuable addition to the initial study design.

From a researcher’s perspective, the student’s reflection provided a valuable learning experience by revealing the depth of engagement and skill development fostered by this educational ER.

One key takeaway was the validation of the ER as a meaningful educational tool, demonstrating its ability to encourage deeper learning and collaboration.

The unexpected insights gained highlight the value of qualitative feedback in evaluating educational interventions. While the ER was designed to enhance problem solving and teamwork, the depth of engagement and personal growth reported by the student exceeded initial expectations.

This, in my opinion, was a missed opportunity: had reflective essays been systematically incorporated into the initial study design, they could have provided richer, more structured qualitative data. This realization suggests the need for future studies to integrate student reflections more intentionally to gain a comprehensive understanding of learning outcomes.

Overall, this was a highly valuable experience, reinforcing the importance of

incorporating diverse data sources when evaluating educational interventions. It also underscored the significance of student voice in shaping and refining pedagogical tools.

3.4 Chapter Summary

ER evaluation in terms of delivery of an effective educational activity was performed using both quantitative and qualitative analyses. The data used to achieve these objectives included: results of OSCE performances and MCQs marks, results of perception Exit Survey and qualitative data coming from the end of activity debrief.

Unexpectedly, one student decided to use the ER as a basis for the mandatory reflective essay on the student's experience during paediatrics (see appendix 1). Comments from this reflective essay from a participant was included in this section as a potentially valuable indicator of the ER's impact on student's learning experience, and will be discussed further, below.

4. DISCUSSION

4.1 Chapter Overview

This chapter focuses on synthesising and analysing the findings in relation to the research aim and the specific study objectives. It discusses the main outcomes of the research, highlighting their implications and contributions to both the field and practical applications. Additionally, the strengths and limitations of the thesis are evaluated, and recommendations for future research in this area are considered.

4.2 Summary of Findings

This study is based on the convergence of an identified literature gap, institutional context, and the researcher's own personal and professional background and clinical teaching experience.

The overall aim of this research is to evaluate how effective ERs are as educational tools for undergraduate healthcare students.

The primary objectives are to explore the role of educational ERs in preparing students for OSCEs and to investigate if gamifying education through ER can deliver effective knowledge acquisition.

Additionally, the study intends to assess how interactive, game-based learning with ER supports leadership, and teamwork skills in healthcare students as well as promotes engagement, and enhances critical and creative thinking under pressure.

Despite all the new emerging literature around the educational role of ERs, there is a lack of information about the correlation between gamifying education through ER and enhancement of OSCEs performance of clinical medical students.

To fill this gap and to estimate the impact of an educational ER on the performance of medical students in an undergraduate course (in my case the Neonatology rotation of the Paediatric course) I designed and performed an educational ER that was played by undergraduate medical students attending their routine neonatal rotation in the Rotunda Hospital.

The literature clearly documents that OSCEs are seen as anxiety-provoking, stressful and constrained with time by students (Muldoon, 2013; Majumder, 2019; Brand, 2009),

and this piece of knowledge led Germa et al (Germa, 2020) to test an online educational game as preparation to reduce students' OSCE-related stress.

Learning to manage stress in a controlled, educational environment equips students with resilience and time management skills crucial for the healthcare profession, where quick, confident decisions can save lives.

My hypothesis is that participating in an educational ER aligned with student's learnings outcomes will reinforce their ability to use their training in high-pressure situations.

To assess that, I combined data from students' OSCEs results after experiencing the educational activity, and to further evaluate if this pedagogical tool can facilitate the acquisition of knowledge, I also analysed the student's MCQs results to reliably assess their acquisition of learning.

The analyses of data from the study revealed several key insights into the educational impact of the ER intervention.

Despite the rigorous analysis, the findings indicate no significant difference between the GER and GRT in both OSCE performances and MCQ scores. This suggests that the ER activity did not result in statistically significant improvements in these measures of knowledge and skills acquisition. However, while there was no significant difference in OSCE or MCQ performance between the intervention group and the control group, the gamified activity did not detract from the performance outcomes. On the contrary, it proved to be a beneficial learning experience, engaging participants in an hour of active learning where they applied clinical skills in a dynamic and interactive setting.

These results demonstrate that educational gamification can enhance the learning experience without compromising performance on traditional assessments. This is in line with the existing literature that proved ERs to be an excellent pedagogical tool for facilitating learning achievement (Millsaps, 2022; 2021; Manzano; Reinkemeyer, 2022; Yang, Wettergreen, 2023; Molina-Torres, 2022, to cite a few).

Furthermore, in comparison to the performance data, the perception exit survey offers an additional perspective, indicating that participants generally viewed the ER activity extremely positively. As a corollary of this perceived effectiveness and enjoyability, as soon as the first group of students participated in the activity, the word of mouth in the Faculty around the ER spread quickly and with great positive energy, creating a steep increment in the request of voluntary participation to the study, from half of the first

group to the almost entirety of the last three groups, including a deep disappointment for those students that were randomised into the control group.

The randomized controlled trial aimed to assess the intervention's effectiveness but unintentionally led to feelings of exclusion among control group participants. To resolve this conflict, the ER experience was offered to these students after data collection was completed.

With respect to the ER perceptions survey, the majority of participants “agreed” or “strongly agreed” that the ER was an effective way to assist their learning and review the topic of neonatology, to learn new information related to neonates and to assist students’ learning around managing a newborn check.

Ninety-three per cent of the participants agreed or strongly agreed that they had learned from their peers during the game-play session. Finally, the majority of participants “agreed” or “strongly agreed” that they would recommend the game to other students.

These survey responses suggest that students found the ER to be a supportive and engaging learning activity that fostered team collaboration, despite the lack of measurable impact on their OSCE and MCQ outcomes.

Most participants perceived the ER as an effective method for reinforcing and reviewing their neonatal skills and knowledge.

Many authors including Morrell, Eukel, Kinio and Brown (Morrell, 2019 and 2020; Eukel, 2017; Kinio, 2018; Brown, 2019) have proved that themed ERs can reinforce prior acquired instruction, and the findings of the post activity questionnaire fully reflects the published literature.

Moreover, the debrief and the participant’s essay, highlighted aspects of the ER that were particularly engaging or challenging, offering valuable feedback on what elements were most effective in fostering learning. In particular, in the additional feedback received from the routine course reflection after the Paediatric rotation, the students highlighted that these skills “are essential within the medical field and they do not believe in the slightest that exam results reflect the benefit of this activity's benefit of use”.

Their thoughts included the perception of effective teamwork, enhancement of personal problem-solving and communication skills, and a high level of engagement and

motivation during the activity, which are key indicators of the ER's impact on their learning experience.

In this study the main focus was on the knowledge and clinical skills acquisition, however, as emerges from the qualitative data collected, educational ERs are an excellent way to promote and enhance a wider professional learning including teamwork, leadership and communication skills.

These findings support the existing literature reinforcing the role of these educational game in fostering students' collaboration and developing communication skills and engagement in critical thinking (Morrell, 2020; Carvalho et al., 2015; Guillén-Nieto, 2011; Šimić et al., 2015).

The exit survey results positively highlight how this novel and enjoyable learning format can increase motivation, encourage retention of knowledge, and strengthen interpersonal skills, all of which are crucial in clinical environments.

4.3 Strengths

One of the key strengths of this study is the large cohort of participants, which enhances the reliability of the findings. Additionally, although there was no significant difference in OSCE performance between the intervention and control groups, the ER activity did not negatively impact performance. Instead, it served as an effective team-based educational tool. Both the students' perspectives and data analysis suggest that participants engaged in an hour of active learning through this educational gamification.

4.4 Limitations

A notable limitation of the study is the variation in assessment, as students were evaluated by two different tutors during their mock OSCEs, potentially leading to inconsistencies. Additionally, the study did not measure participants' competencies before and after the intervention, making it unclear whether there was an improvement in their baseline skills and knowledge. Future research could address this by assessing the effectiveness of the ER through pre- and post-intervention testing within the same cohort to determine any measurable improvement.

The OSCE outcomes assess a range of competencies, including clinical skills, attitudes, problem-solving abilities, and knowledge application in simulated environments.

Typically, OSCE evaluations differentiate between multiple domains such as professionalism, skills, and knowledge. However, in this study, a global score that combines these domains into a single number was used. This approach could affect the results, as it does not account for variations in individual performance across different domains. For instance, a student who excels in skills and professionalism but struggles with knowledge might receive the same overall score as someone with opposite strengths and weaknesses.

Due to the non-mandatory participation for the mock MCQ, responses were only 38 among the participants of the study. The small size of this cohort constitutes a limiting factor for the outcomes' analyses. In future a larger cohort of cases is warranted to explore the effect of gamification in knowledge acquisition.

Given the relatively short-term data collection, the study was limited in its ability to evaluate long-term knowledge retention and skills development. While the quantitative results provide valuable insights into short-term learning gains, they do not capture how well students retain and apply this knowledge over time.

A longitudinal study could offer a more comprehensive understanding of the ER's impact on long-term and deep learning performance. By assessing participants at multiple time points, researchers could determine whether the problem-solving and teamwork skills reinforced by the ER lead to sustained improvements in clinical reasoning and decision-making. Additionally, longitudinal data could provide insights into how experiential learning translates into real-world applications, addressing whether students continue to integrate these skills into their medical practice.

Another limitation is the lack of control for potential confounding variables, particularly those related to individual dispositions or interpersonal skills of the participants. These factors could influence engagement and competitiveness in the ER, potentially biasing the results.

The unexpected information provided in the reflective essay, written by one student as part of paediatric course requirements, provided additional support for the ER approach. The usefulness of this reflection to contextualise the overall results may reflect a missed opportunity to listen more comprehensively to the learner's voice in the aftermath of this study, this should be considered in future study design.

Future research should consider exploring these variables descriptively to determine whether they predict enjoyment or resistance to such gamified learning experiences.

4.5 Conclusions

Overall, while the quantitative performance data did not show significant gains, the results of the post-activity survey and the qualitative feedback highlights the potential of ERs as a valuable educational tool for enhancing student engagement and perceived learning. These findings suggest that while ER may not directly improve exam performance, they could play an important role in enriching the learning experience and promoting active, team-based learning. An aspect worth considering, though beyond the scope of this study, is the limitation of OSCE assessments in evaluating soft skills. During the ER debriefing, participants emphasised that teamwork, mutual respect, and communication were crucial to their success, suggesting that ERs could serve as an effective alternative for improving and assessing these skills.

In this research project, however, I focused on measuring knowledge and clinical skills, without assessing broader aspects of professional learning such as time and management, teamwork and leadership, and communication. While these elements are crucial to healthcare practice, they were not evaluated in this study, which may limit our understanding of the full impact of the educational role of ERs on professional competencies.

In conclusion, ERs represent an innovative learning strategy that promote active student participation, stimulate curiosity, and foster engagement. They create opportunities for positive collaboration and meaningful learning. The evaluation suggests that educational ERs can complement or supplement traditional teaching methods as a motivating and innovative learning strategy. Most participants found the ER to be highly motivating and enjoyable, helping to reinforce their knowledge of the subject. Additionally, students recognised the potential of ERs as a playful way to assess their knowledge.

4.6 Next steps

The next step in this educational development is to implement this ER within the curriculum of the RCSI. This would involve collaborating with faculty members and curriculum designers to integrate the ER into the existing medical program, particularly within the neonatal clinical rotations.

Pilot sessions could be conducted with small groups of students to refine the activity's structure, and its timing within the teaching schedule already in place.

Following successful integration into RCSI's curriculum, I would like to explore the expansion of the ER to other universities and healthcare institutions.

To facilitate this, a structured training program could be developed to support faculty members and staff in delivering the ER, ensuring consistency and quality across institutions. Partnerships with other universities could be established, allowing for a multi-center study that further evaluates the impact of ERs on student outcomes across a variety of educational settings.

Simultaneously, it would be valuable to investigate the potential commercialization of the ER. This could involve developing physical kits that can be licensed to universities and healthcare institutions. Marketing efforts could focus on the growing demand for innovative, interactive educational tools in medical training.

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Appendix 1: Additional Information in Routine Course Reflection after the Study.

Escape Rooms – Definitely for Learning

Description/Analysis:

For this reflection I decided to write about something unconventional for me to typically ruminate on. At this point in time, I have now been studying medicine for the past 5 years, yet undoubtedly, I have had the most profound learning experiences throughout my time in paediatrics. Don't get me wrong, I have learned so much over the last few years and am so grateful for my time at RCSI and have had extremely profound individual learning experiences. Nevertheless, during paediatrics I was pushed to practise my skills through problem solving and actively engaged learning with my fellow classmates which ultimately made me feel "alive" within my learning environment. From the incredibly engaging SIMS to the lively team, I was placed with at Crumlin (Nephrology) it continuously made me feel like I was actively learning and involved. However, despite all the absolutely amazing practical learning experiences there is one in particular I would like to highlight as I think it should not only continue (as my understanding it was only a trial) but should be included into most learning experiences to some capacity. During my week of neonatology, I hesitantly agreed to join a study on the benefit of escape rooms to learning. This particular experience is one I won't forget, because for the first time in a long time I felt like I was genuinely problem solving and "thinking outside the box". Thus, I felt that it was important that I attempt to emphasise its benefit so that hopefully it will be continued. Overall, it pushed a group of medical students to not only rely on our knowledge, but simultaneously force us to practise skills we rarely (or at least rarely effectively) practice. Some of these include:

1. Relying on the skillsets of all group members:

Each clue was very different from the last and each member of the team was able to use their individual skills to help solve the numerous puzzles we were faced with. This has so much unrecognised benefit as it reflects the cooperation of a multidisciplinary team and how each member works towards a common goal. I saw every member of my group utilising their own skills to aid the collective. It would have taken at least twice as

long to have done it alone, at that independently showed the importance of us all being able to work together.

2. Thinking beyond the scope of regurgitating information:

Medical knowledge was highly important in this game; however it was not the absolute towards finding the answer. Thus, it forced a more complex view outside of the textbook information. I believe this is similar to how each patient and situation is very different from the last and it is important to analyse each situation as a complex individual or situation rather than a flowchart we need to follow the steps for (however, I do understand the importance of standard of care and this does not dissolve the pre-set and researched steps, rather, there are still factors that are individual patient that are not about only textbook regurgitation of information)

3. Problem solving:

The escape room provided complex and medically based puzzles that forced thinking outside of memorization. Instead, it required interpreting information, analysing it effectively, and then deducing collaboratively what the next best steps were. Every aspect of the escape room was different to the previous. There was no way to prepare which is what was so great about it, it forced genuine problem solving based on previously memorised knowledge.

Feelings/Evaluation:

The escape room (and to clarify it was before my week at Crumlin, which was also great for engaging learning experiences) made me start to remember why I chose medicine in the first place. I felt genuinely pushed in a different way than I have in a while. I felt so engaged and it forced me to think “outside of the box”. While I definitely see the importance in reflections and other written assignments, I don’t think they can compare to an activity that forces genuine creativity and thinking outside of the pre-constructed “box”. For a kinaesthetic learner like me in particular it was incredible, and I felt so genuinely focused and engaged. I can only speak for myself, but I saw every member of my group despite their typical “learning style” coming alive through this activity. Overall, it was such a rewarding experience and my teammates, and I worked far better together within the rest of paediatric situations and had more of an appreciation for each other.

Conclusion:

A specific lesson I have left frequent placements being told and knowing I need to improve on to “speak up” and to “be more confident”. I am genuinely grateful for the way paediatrics was set up, because I have seen myself pushing back outside of my shell and becoming more assured with the knowledge I know. This may have been an untraditional reflection, but I wanted to express my gratitude to how this placement has pushed me to actively think and engage. I am leaving it feeling more rejuvenated and ready for future placements due to the practical experiences provided and problem-solving activities which improved my confidence and engaged me in the learning process.

Action plan:

I wrote this hesitantly in hope that this type of learning environment is continued to be used and broadened to other areas. This does not only include the escape room, but also the SIMS situations throughout paediatrics that helped incredibly in preparing us not only for paediatrics, but for medicine in general.

From my understanding this study's outcome measurement was based on the results on the paediatric exam. However, unfortunately, I do not believe it does it justice.

Escape rooms for learning go far beyond regurgitating information, but a practised skill within engaged group collaboration. These are all skills I believe are essential within the medical field and I do not believe in the slightest that exam results reflect the benefit of this activity's benefit of use.

Appendix 2: Participant Information Sheet



Project title: Escape to learn: the effectiveness of escape rooms for engagement and learning outcomes of undergraduate medical students. A randomized controlled trial.

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Participant Information Sheet

Introduction

You are being invited to take part in a research study to be carried out at the Rotunda Hospital by Dr Alessandra Biagini. The study will explore the effectiveness of the use of an educational escape room to deliver effective long-term learning to clinical medical students.

An escape room is an immersive cooperative live-action game, in which teams of players achieve a specific goal (usually to escape from the site of the game) in a limited amount of time through solving a crescendo of clues, puzzles, and various tasks.

Before you decide whether or not you wish to take part, you should read the information provided below carefully and, if you wish, discuss it with your family or friends. Take time to ask questions – don't feel rushed and don't feel under pressure to make a quick decision.

You should clearly understand the risks and benefits of taking part in this study so that you can make a decision that is right for you. This process is known as 'Informed Consent'.

You don't have to take part in this study, and you can change your mind about taking part in the study any time you like. Even if the study has started, you can still opt out and you

don't have to give us a reason. If you decide not to take part, we assured it won't affect your past, present or future academic outcome in anyway.

Please take the time to read the following information carefully and feel free to ask the researcher any questions that you might have.

What is the purpose of the study?

The aim of this research is investigating the impact of using an escape room to deliver an effective long-term learning of clinical medical students.

I intend to question if this interactive game-based learning experience can facilitate the acquisition of knowledge, leadership, and teamwork competencies in undergraduate healthcare profession students and to explore the impact of an educational escape room as a new educational tool on the OSCE and MCQs performance of clinical medical students.

Why have I been invited to take part in the study?

You have been asked to take part to this study because you are an undergraduate RCSI student attending the neonatal teachings in the Rotunda Hospital as part of the Paediatric course, during the academic year 2023-2024.

Do I have to take part?

Participation in this study is entirely voluntary. There will be no adverse consequences associated with declining to take part or withdrawing from the study. You can withdraw from this study without giving a reason; however, it should be noted that this will not be possible once data has been pseudo-anonymized. The cut-off date for withdrawal from the study is September the 1st, 2023.

What will my involvement require?

If you decide to participate to this study, you will be randomly assigned either to the group of participants that will actively participate to the escape-room experience in

addition to the traditional teaching (total duration estimation maximum 1 hour), or to the group of students that will participate to the routine teaching schedule planned for the rotation.

If you are in the group that will experience the escape room, this means that you will be part of a team of players (peer students) and together with your teammates you will need to solve content-specific challenges to attain clues which lead to the next challenge or obstacle. The quizzes will focus on neonatal issues, and they will reproduce the hurdles in management and leadership of our everyday profession. They will also include academic baseline knowledge to reinforce the topics covered during the teaching sessions. The escape room will last a maximum of 1 hour, it will be organised during the week of your attendance to the hospital, and it is an addition to the routine schedule expected for your neonatal rotation.

The escape room is not meant to be physically demanding and no force is required for any of the puzzles; the experience can be subjected to individual sensibility in terms of pressure or stress. A distress protocol will be given to all the participants.

If you are in the group that will not experience the escape room, you will have 1 hour of protected time to study and practice your clinical skills on a mannequin in group of 5-7 students. This will happen in addition to the traditional teaching schedule planned for your rotation. After your mock examinations, and at the end of your rotation in Neonatology, you will be given the opportunity to perform the escape room, if you are wishing to experience it.

At the time you accept to participate to this project you will not know what the group you will be allocated to is. This will be revealed during your attendance in the hospital.

Either if you will be allocated in one group or in the other, at the last day of your Neonatal rotation, you will be asked to complete a questionnaire with the aim of exploring your reflection upon your learning experiences. If you are participating to the escape room, the questionnaire will also include questions relative to the experience.

Also, pseudo anonymized performance data from the routine mock OSCE and MCQ assessments (mandatory to all the students) will be collected and analysed exclusively for the purposes of this research project.

Your active involvement in the study will last about one hour and a half, and this time will include the time of the escape room experience, a little debrief session at the end of this experience and of the completion of the questionnaire.

The escape room will be organised in one of the educational rooms of the Rotunda Hospital, during your attendance as part as the mandatory Paediatric course.

The researcher, Dr Alessandra Biagini, will be present during all the escape room experience and available if you may need any further questions.

If you have a concern about any aspect of this research, you can directly you can directly present your complaint to the researcher or you can contact the researcher via email: alessandrabiagin21@rcsi.ie

What are the possible disadvantages or risks of taking part?

The risks of participation in the study are very low and of a social nature. This research will be GDPR compliant, and all the efforts will be made to avoid data protection breeches. The escape room is not meant to be physically demanding, and no force or physical requirement is requested for any of the puzzles. The escape room experience can be subjected to individual sensibility in terms of pressure or stress.

There are no risks in completing the questionnaire or the analysis of the assessments.

A potential risk could be an inequality between the students that participates to the escape room versus the students that will not experience it. To avoid this, in the eventuality you will be in the group not allocated to the escape room experience, you will be given the opportunity to perform it, after the completion of the mock examinations.

The outcomes of the mock exams will be intended only as feedback and will not impact on student's evaluation or marks.

What are the possible benefits of taking part?

It is aimed that the escape room experience will develop teamwork and collaboration as they push different staff members into a playful, collaborative effort based on sharing expertise, knowledge, and skills aimed to create a positive outcome. Further benefit can come from the reinforcement of acquired knowledge during the puzzle solving.

Each participant can benefit from the co-operative environment and the teamwork and from sharing information and expertise.

What happens when the research study stops?

It is aimed that data obtained from this project will contribute towards one research paper in the peer-reviewed health professions' literature.

Will my taking part in the study be kept confidential?

Yes, all the information you give will be encrypted, pseudo-anonymised, and kept confidential. Results from this research will be reported in a way which ensures that the unique identity of participants is not disclosed. Personal data will be handled in accordance with the Data Protection Act (2018). Specifically, this means that:

- We will be using your personal information in our research to help us explore effectiveness of escape rooms as an educational tool to improve long and short-term learning.
- Your data will be processed for scientific research purposes.
- The recipients of the data will be Alessandra Biagini, Jenny Moffett, Naomi McCallion and Jan Illing.
- The data will be stored for no longer than five years, after which it will be destroyed.
- Once the study will be published the file will be permanently deleted by the Researcher.
- No prints or paper sheets with sensitive data will be produced.
- In the unlikely event of a data breach, none of your personal data would be identified.
- You can withdraw your consent at any time by emailing Alessandra Biagini at alessandrabiagin21@rcsi.com.
- At any time, you have the right to withdraw your consent for this study. In this case all the information that you provided for this research will not be used for the study and will be destroyed.
- As a participant, you have the right to lodge a complaint with the Data Protection Commissioner.

- At your request, we will provide you with access to your data and a copy of it.
- As a participant, you have the right to restrict or object to the processing of your data.
- At your request, we will correct or delete any data which you feel is inaccurate.
- At your request, we will delete any of your personal data, so it is not to be used in the study. (Noting that the cut-off date for withdrawal from the study is 30/05/2022).
- At your request, we will move your data to another controller.
- No automated decision-making, including profiling, will be made with your data.
- No automated processing will be used for this study.
- In case the researcher intends to further process your personal data you will be promptly informed, and you will be provided with information on that other purpose.
- You will be promptly informed if the researcher needs or wish to transfer your data to a country outside the EU or an international organisation, and you will be advised of the safeguard measures that will be put in place at that time to protect your data.

What if there is a problem?

Any complaint or concern about any aspect of the way you have been dealt with during the course of the study will be addressed; If you need any further information now or at any time in the future, please contact Alessandra Biagini, Principal Investigator, on 01 817 1700, or via email to alessandrabiagini21@rcsi.com. You may also contact the Director of HPEC (Health Professions Education Centre, RCSI), Prof. Jan Illing, on 01 402 2565.

Contact details:

Alessandra Biagini

Rotunda Hospital

Parnell Square

Dublin 01

Tel: 01 817 1700

Email: alessandrabiagini21@rcsi.com

Who has reviewed the project?

The study has been reviewed and received a Favourable Ethical Opinion (FEO) from the RCSI Research Ethics Committee, application number 212617279.

Thank you for taking the time to read this information sheet.

Appendix 3: Participant Consent Form.



UNIVERSITY
OF MEDICINE
AND HEALTH
SCIENCES

Project title: Escape to learn: the effectiveness of escape rooms for engagement and learning outcomes of undergraduate medical students. A randomized controlled trial.

REC Number: 212617279

Principal investigator: Alessandra

Biagini Email address:

alessandrabiagini21@rcsi.com

Supervisor: Dr Jenny Moffett, Prof. Jan Illing, Prof. Naomi McCallion

Telephone number: 01 817 1700

PARTICIPANT CONSENT FORM

Escape to learn: the effectiveness of escape rooms for engagement and learning outcomes of undergraduate medical students. A randomised controlled trial.

I have read and understood the Information Leaflet about this research project. The information has been fully explained to me and I have been able to ask questions, all of which have been answered to my satisfaction.	Yes ☐	No ☐
I understand that I don't have to take part in this study and that I can opt out at any time. I understand that I don't have to give a reason for opting out and I understand that opting out won't affect in any way my evaluation or my academic outcome.	Yes ☐	No ☐
I give permission for researchers to look at the results from the performance of the mock OSCE/MCQs to get information. I have been assured that information about me will be kept private and confidential.	Yes ☐	No ☐
I have been given a copy of the Information Leaflet and this completed consent form for my records.	Yes ☐	No ☐
I consent to take part in this research study having been fully informed of the risks, benefits, and alternatives.	Yes ☐	No ☐
I give informed explicit consent to have my data processed as part of this research study.	Yes ☐	No ☐
I consent to be contacted by researchers as part of this research study.	Yes ☐	No ☐

FUTURE CONTACT		
I consent to be re-contacted by researchers about possible future research related to the current study for which I may be eligible.	Yes ☐	No ☐
I consent to be re-contacted by researchers about possible future research unrelated to the current study for which I may be eligible.	Yes ☐	No ☐

STORAGE AND FUTURE USE OF INFORMATION		
RETENTION OF RESEARCH MATERIAL IN THE FUTURE [please choose one or more as you see fit]		
I give permission for data to be stored for <u>possible future research related</u> to the current study <u>only if consent is obtained</u> at the time of the future research but only if the research is approved by a Research Ethics Committee.	Yes ☐	No ☐
I give permission for data to be stored for <u>possible future research related</u> to the current study <u>without further consent being required</u> but only if the research is approved by a Research Ethics Committee.	Yes ☐	No ☐
I give permission for data to be stored for <u>possible future research unrelated</u> to the current study <u>only if consent is obtained</u> at the time of the future research but only if the research is approved by a Research Ethics Committee.	Yes ☐	No ☐
I give permission for data to be stored for <u>possible future research unrelated</u> to the current study <u>without further consent</u> being required but only if the research is approved by a Research Ethics Committee.	Yes ☐	No ☐

_____	_____	_____
Student Name (Block Capitals)	Signature	Date

To be completed by the Principal Investigator or nominee.

I, the undersigned, have taken the time to fully explain to the above participant the nature and purpose of this study in a way that they could understand. I have explained the risks involved as well as the possible benefits. I have invited them to ask questions on any aspect of the study that concerned them.

_____	_____	_____	_____
Name (Block Capitals)	Qualifications	Signature	Date

<i>Please select the choice with which you most agree:</i>					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
1. The escape room encouraged me to think about material in a new way.					
2. I would recommend this activity to other students.					
3. I learned from my peers during the neonatal escape room.					
4. The escape room was an effective way to review the topic of neonatology.					
5. The escape room was an effective way to learn new information related to neonates.					
6. I learn better in a game format than in a lecture.					
7. The escape room was an effective way to assist my learning around managing a newborn check.					
8. I feel I was able to engage with my teammates to learn new material.					
9. It was difficult for me to focus on learning because I was feeling stressed or overwhelmed.					
10. The non-educational portions (e.g., puzzles, etc.) distracted me from learning about neonates.					
11. I prefer assembling information from a variety of sources when learning new material.					
12. In general, I enjoy playing games (video games, board games, social media games, etc.).					

Appendix 5: Research Ethics Committee Approval



Royal College of Surgeons in Ireland
The Research Ethics Committee
111 St. Stephens Green, Dublin 2, Ireland
Tel: +353 1 4022205 Email: recadmin@rcsi.ie

Prof Declan Patton (Chair)
Dr Niamh Clarke, Convenor

Private and Confidential

Dr Alessandra Biagini
20 MARCH 2023

HREC Reference Number	REC202211032
Project Title	Escape to learn: the effectiveness of escape rooms for engagement and learning outcomes of undergraduate medical students. A randomized controlled trial.
Researcher Name (lead applicant):	Alessandra Biagini
Principal Investigator:	Alessandra Biagini
Other Individuals Involved::	Janet Christina Illing Jenny Moffett Naomi McCallion

Dear Alessandra Biagini

Thank you for your Research Ethics Committee (REC) application. We are pleased to advise that ethical approval has been granted by the committee for this study.

This letter provides approval for data collection for the time requested in your application and for an additional 6 months. This is to allow for any unexpected delays in proceeding with data collection. Therefore, this research ethics approval will expire on 03 DECEMBER 2024.

This ethical approval is given on the understanding that:

- All personnel listed in the approved application have read, understand and are thoroughly familiar with all aspects of the study.
- Any significant change which occurs in connection with this study and/or which may alter its ethical consideration must be reported to the REC, and an ethical amendment submitted where appropriate.
- **A final report will be submitted to the REC upon completion of the project.**

Please note it is the responsibility of the Data Controller/Joint Data Controllers/PI and relevant Data Protection Officer to ensure and monitor compliance with relevant data protection legislation and regulation.

Please liaise with relevant data protection officer(s) with regard to progress in relation to your Data Protection Impact Assessment.

Receipt of research ethics committee approval is not, and should not be regarded as evidence of compliance with GDPR 2016 or the Health Research Regulations 2018.

We wish you all the best with your research.

Yours sincerely,

A handwritten signature in blue ink that reads "Niamh Clarke". The signature is written in a cursive, flowing style.

PP Dr Niamh Clarke (Convenor)
Dr David Smith (Acting Chair)

Appendix 6: mock MCQs

1. A 1 week old baby, ex 32 weeks of gestation has vomited the last two feedings and is less active. Your examination reveals a tense, distended abdomen with decreased bowel sounds. The nurse refers that he has a grossly bloody stool. Your management of this infant should include

- a) Continued feeding of the infant, as gastroenteritis is usually self-limited
- b) Stool culture to identify the etiology of the bloody diarrhea and an infectious diseases consultation
- c) Upper GI series and barium enema to evaluate for obstruction
- d) Immediate surgical consultation for emergency laparotomy of the obstructed bowels
- e) Stopping feeds, beginning intravenous fluids, ordering serial abdominal films, and initiating systemic antibiotics

2. During a routine baby check on a 3 days old baby you notice that baby's femoral pulses are absent. What is your next step of management?

- a) Book a follow up appointment in clinic
- b) Administer paracetamol intravenously
- c) Organise an outpatient ECHO with the paediatric cardiologist
- d) Perform a chest Xray
- e) Administer prostaglandin via continuous infusion

3. A newborn baby is showing epicanthal folds, upslanting palpebral fissures, thickened nuchal skin folds, and relative macroglossia.

What investigation are you going to perform?

- a) FISH
- b) Electrolytes and CRP
- c) Karyotype
- d) PCR
- e) Microarray

4. A G1 P0 woman has blood type O positive. She gives birth to an infant who is A-positive. At 36 h of age the baby develops jaundice. Which of the following laboratory findings would you expect in this baby?

- a) A normal reticulocyte count
- b) A positive direct Coombs test
- c) Crescent-shaped red blood cells in the blood smear
- d) Elevated haemoglobin
- e) Petechiae

5. You examine a 1-day-old infant who born operatively via forceps delivery. At examination her left arm is internally rotated by her side with the forearm extended and

pronated; Moro reflex is negative. The rest of her physical examination is normal. What investigation should you perform on this baby?

- a) MRI
- b) CT
- c) Chest Xray
- d) Ultrasound
- e) PET

6. A 2 day old term baby has being noted having the head circumference of 30cm. What investigation would you request for this baby?

- a) Urine Cytomegalovirus
- b) None. Give parental reassurance
- c) Septic screen
- d) Toxoplasma serology
- e) Direct Coombs test

7. During a routine baby check you palpate a liver 2 cm below the costal edge. What is the next step of your management?

- a) Baby need urine CMV to rule out a congenital infection
- b) You will organise an abdominal USS to investigate the finding
- c) The baby will need a close follow up to check for jaundice
- d) You will perform liver function test on this baby to further evaluate the finding
- e) You will give reassurance to the parents

8. A 1-week-old African infant presents to you for the first time with a large, fairly well-defined, purple lesion over the buttocks bilaterally. The lesion is not palpable, and it is not warm or tender. The mother denies trauma and reports that the lesion has been present since birth. This otherwise well-appearing infant is growing and developing normally and appears normal upon physical examination. The most likely diagnosis in this infant is

- a) Non accidental injury
- b) Mongolian blue spot
- c) Subcutaneous fat necrosis
- d) Vitamin K deficiency
- e) Haemophilia

9. A newborn infant develops respiratory distress immediately after birth. His abdomen is scaphoid. No breath sounds are heard on the left side of his chest, but they are audible on the right. Immediate intubation is successful with little or no improvement in clinical status. The most likely explanation for this infant's condition is

- a) Pneumonia
- b) Cyanotic heart disease
- c) Choanal atresia
- d) Diaphragmatic hernia

e) Pneumothorax

10. A previously healthy full-term infant has several episodes of duskiess and apnea during the second day of life. Diagnostic considerations should include which of the following?

- a) Haemolytic anaemia
- b) Congenital heart disease
- c) Idiopathic apnoea
- d) Harlequin syndrome
- e) Hyperglycaemia

11. A 2-hour-old full-term newborn infant is having episodes of cyanosis and apnea. During feeds his oxygen levels drop into the 60s. When he is stimulated and cries, his oxygen levels increase into the 90s. Which of the following is the most important next step to quickly establish the diagnosis?

- a) Echocardiogram
- b) Ventilation perfusion scan
- c) Passage of naso-gastric tube into nose
- d) Haemoglobin electrophoresis
- e) Bronchoscopic evaluation of palate and pharynx

12. You are examining a newborn infant when you notice that the measurement of fronto-occipital head circumference is about 2 cm larger than the initial measurement done several hours before. The baby was born via operative SVD (ventouse). At examination the infant has a heart rate of 198 and the scalp has a fluctuant lump on the occipitus. Management of this condition should include which of the following?

- a) Transfer to the newborn ICU
- b) Observation on the postnatal ward and parental reassurance
- c) Emergency CT scan of the skull with bone windows
- d) Surgical drainage
- e) Elevation of the head of the crib

13. Which of the following congenital heart defects is characterized by a machinery-like heart murmur in a neonate?

- a) Patent ductus arteriosus
- b) Tetralogy of Fallot
- c) Ventricular septal defect
- d) Transposition of the great arteries
- e) Coarctation of the aorta

14. An ex term baby comes in your clinic. Her clinical examination is unremarkable. You elicit that even with sudden stimuli, the baby does not abduct the upper extremities nor extend the arms, with no fingers extension, and no cry. You notice his age and it is:

- a) <1 month
- b) 1-2 months

- c) 2-4 months
- d) 4-6 months
- e) >6 months

15. What of the following needs an immediate referral to the surgical team?

- a) Polydactyly
- b) Imperforated anus
- c) Cryptorchidism
- d) Auricular skin tags
- e) Hypospadias

16. What is the pathognomonic sign of aortic coarctation in a newborn baby?

- a) Brachio-femoral delay
- b) Continuous murmur
- c) Absent femoral pulses
- d) Acrocyanosis
- e) Sustained tachycardia