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BRIDGING THE DIGITAL DIVIDE WITH A GAME-BASED APPROACH

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ABSTRACT

The digital divide remains a pressing issue, particularly for older adults, who face barriers to accessing and effectively using digital technologies. This study explores game-based assessment (GBA) and learning (GBL) as blended learning approaches to bridge this divide by fostering digital competencies in an engaging and supportive environment. DiGiUP is a game-based approach developed specifically for older adults to support and evaluate the development of their digital competencies. It uses a narrative-driven design by offering players to navigate real-world scenarios requiring digital problem-solving skills. Testing, conducted within the Erasmus+ project DIGIBLEND, involved 45 older adults in structured gameplay sessions, joined by pre/post-game evaluations. Results, both qualitative and quantitative, revealed significant improvements in digital skills, particularly in problem-solving, along with increased confidence in navigating digital environments. Participants reported high enjoyment and engagement, with collaborative learning emerging as a key factor in the games' success. These findings enrich lifelong learning research with practical insights for designing inclusive, effective digital competence programs.

KEYWORDS

Game-Based Assessment, Game-Based Learning, Digital Competences, Blended Learning

1. INTRODUCTION

Digital technology is essential aspect of everyday life, providing opportunities for communication, information access and task management. With the proliferation of digital devices and the internet in most parts of the world, knowledge and skills to use them in everyday life and at work have become crucial for almost everyone. These skills reflect not only the respective knowledge of information and communication technologies (ICT), but also the ability to use the technologies effectively and responsibly. Therefore, the development of digital skills is at the top of the European digital agenda (European Commission, 2024; Sala et al., 2020).

More than a fifth (21.53 %) of the EU population in 2023 was aged 65 and over, with estimation for growth over the next three decades, peaking at 129.8 million in 2050 (Corselli-Nordblad & Strandell, 2020). The lack of digital competence among older adults in the EU is a significant factor for the emergence of the second digital divide. Unlike the first digital divide associated with disparities in economic development, the second is rooted in technological skills and access (Reissmann et al., 2022). On the other hand, only 28% of the European older adults possess basic digital skills, leaving the majority feeling as outsiders in the European digital culture (DESI, 2024). Although this percentage varies across countries, the numbers are important indicator for a significant portion of European citizens not possessing the digital competences needed for regular activities.

The problem of adopting digital skills among older adults is rooted in their prior learning and professional experiences, which lacked exposure to digital technology and internet services (D. B. Clark et al., 2016; Schirmer et al., 2023). Thus, they are largely unfamiliar with modern devices despite their usefulness for facilitating social connections and managing daily tasks (Blažič & Blažič, 2020; Oppl & Stary, 2020). Many older adults approach these devices with apprehension, fearing the potential consequences of their lack of digital knowledge (Team, 2020). When faced with the need to use new technologies, they rely on public day centers for assistance with tasks that may seem simple to others but remain challenging for them.

Traditional instructional methods often fall short in addressing the specific challenges faced by older adult learners, as they may not fully accommodate the diverse needs. Research shows that older adults benefit from learning environments that are engaging, non-intimidating, and adaptable to their individual abilities (Casselden, 2023). In this context, game-based assessment (GBA) and game-based learning (GBL) emerge as promising solutions. By blending structured learning objectives with interactive and enjoyable game mechanics, GBA and GBL create a motivating environment that encourages exploration and reduces the fear of failure (Kim & Ifenthaler, 2019). GBA and GBL thus create supportive environments where older adults can build confidence and acquire digital skills at their own pace.

This paper presents an empirically driven game-based approach for development of an educational game for learning and assessing digitals skills for older adults, named DiGiUP. The game employs a narrative-driven approach by simulating real-world scenarios where participants apply their digital knowledge to solve challenges. Designed to promote engagement and confidence, DiGiUP combines analog and digital elements to create an interactive environment that addresses older adults' unique needs. This study evaluates the game's effectiveness in improving and assessing digital competencies, fostering enjoyment, and identifying refinements for future iterations. By leveraging the potential of game-based learning, DiGiUP contributes to bridging the digital divide and promoting lifelong learning and social inclusion among older adults. The study is situated within the framework of the European Commission's DigComp 2.2, which defines digital competence as a multifaceted skill set encompassing information and data literacy, communication, safety, and problem-solving (Vuorikari et al., 2022). These competencies are vital for older adults to navigate today's digital landscape confidently. Yet, existing educational tools often fail to effectively engage this demographic, leaving a gap in practical, scalable solutions.

2. BACKGROUND

The advancement of digital technology has transformed many aspects of modern life, creating a pressing need for digital literacy across all demographics, including older adults. Digital competence is not only a critical skill for accessing information and communication technologies (ICT) but also a key enabler for participation in a rapidly evolving digital society. This section outlines the theoretical foundations that inform the design and evaluation of game-based learning/assessment interventions aimed at evaluating and improving digital skills among older adults.

Game based assessment can be defined as the process of evaluating or measuring someone's (digital) knowledge, skills, competencies or progress in a particular area through the use of games (Udeozor et al., 2024). It involves gathering evidence of learning through various methods and making judgments based on that evidence. Research has emphasized the potential of GBA to offer real-time insights into learners' progress while maintaining engagement through gamified elements (Landers et al., 2017; Mislevy et al., 2012). Compared to traditional assessments, GBA allows for a more nuanced evaluation of cognitive and behavioral skills, particularly in digital literacy (A. Pak, 2024). More specifically, games can be an effective tool for assessment in several ways:

1. **For knowledge assessment** (D. B. Clark et al., 2016), where they assess a learner's knowledge and understanding of specific concepts or subjects. For example, quiz games or interactive simulations can present questions or scenarios that require players to apply their knowledge to progress or score points.
2. **For skill assessment** (Kim & Ifenthaler, 2019; Shute & Ke, 2012)**,** to evaluate a player's skills, such as problem solving, critical thinking or decision-making. Puzzle games, for example, can assess logical thinking and strategy skills. In contrast simulation games can assess decision-making abilities in various scenarios.
3. **For behaviour assessment** (Landers et al., 2017), by evaluating a player's behaviour, attitudes, and social skills. For instance, role-playing games or multiplayer games are excellent for assessing how players interact communicate, and collaborate with others.
4. **For performance assessment** (Mislevy et al., 2012)**,** involving completing tasks or achieving objectives to assess a player's efficiency and ability to practically apply learned concepts or skills.

Digital competence refers to the confident and critical use of ICT for work, leisure, and communication. According to the DigComp Framework (see Figure 1), digital competence encompasses five key areas:

- Information and data literacy: The ability to identify, locate, retrieve, evaluate, and use information effectively.
- Communication and collaboration: Engaging in digital environments for collaboration, interaction, and participation.
- Digital content creation: Creating, editing, and managing digital content.
- Safety: Ensuring online privacy, security, and well-being.
- Problem solving: Innovatively resolving issues using digital tools

Our approach focuses on the three areas: *information and data literacy, safety,* and *problem-solving*, as they have been proven to address critical everyday needs of older adults with lower level of digital proficiency (Oh et al., 2021). To do that, the specification of game

elements in our approach follows the MDA (Mechanics, Dynamics, and Aesthetics) design framework for defining the basic elements of the game-based approaches (Hunicke et al., 2004).

Mechanics represent the main components of the game: rules, actions required by the player in order to play the game, the algorithms and data structures in the game engine, etc. *Dynamics*, on the other hand, are the behaviours manifested during the game-play, as well as the factors affecting the player input and their "cooperation" with others' game-play. Finally, a*esthetics* is represented by the emotional responses that the game-play evoked in the player as a result of all other elements. Although aesthetics is largely subjective across players, as each player is differently affected by the game, some common player states noted in the literature are: sensation, fantasy, narrative, challenge, fellowship, discovery, expression, and submission.

Game-based learning (GBL) integrates instructional content into game mechanics to enhance learning outcomes. It leverages the motivational and interactive elements of games, such as challenge, feedback, and progression, to facilitate active engagement with the learning material (Dubbels, 2013). The effectiveness of GBL in improving digital skills stems from its ability to: create a safe and enjoyable learning environment that reduces fear of failure; support incremental learning, where players advance through increasingly challenging tasks; and promote collaborative learning, enabling peer-to-peer interaction and mutual support. Evidence-based studies have already demonstrated the potential of GBL to bridge the digital divide for older people (Kim & Ifenthaler, 2019).

Game-based assessment has increasingly served as a bridge to close the knowledge and confidence gaps for older populations, as it focuses specifically on their capabilities while directing the learning process towards motivation and engagement. Unlike traditional GBL principles, the GBA approach is focused more on entertainment and learner engagement. This allows to unravel older adults' abilities in a customized way through particular test construction principles integrated into the knowledge assessment protocols.

3. RELATED WORK

Over the last decade, there is an increasing number of initiatives and research efforts aimed at enhancing social inclusion of older adults and promote their involvement in society (Casselden, 2023; Oppl & Stary, 2020; Vuorikari et al., 2022). However, research detected an innate reluctance in older adults to engage due to the general attitude that they cannot learn new matter as easily as younger people (Schirmer et al., 2023). Furthermore, the fast-paced digital world is regarded as the realm of future generations, the so called "digital natives", as they are growing up with smartphones and the internet, while the majority of older adults tend to perceive as alien the new digital technologies that constantly emerge (L. S. Clark, 2012). Moreover, many struggle with the general concept of fast-changing knowledge that devalues their own skills and competencies acquired in the past as part of their educational achievements. Some of the major factors for exacerbating their fear of using technology are of systemic nature: when people reach retirement age, organized access to education ceases to exist and the continuity of education mainly depends on the intrinsic motivation of individuals and the available support (Reissmann et al., 2022).

In their study, Casselden (2023) emphasize the need for a suitable learning environment for enabling successful digital literacy training for older adults capable of reducing their reluctance to technology use. They also highlight the importance and usefulness of simplicity of the

learning approach. Game-based learning and assessment have significant potential to address this digital divide by offering engaging, low-pressure environments for skill development (D. B. Clark et al., 2016; Kim & Ifenthaler, 2019). While an important part in a game's application is the assessment of knowledge acquired by players, emotional signals should be integrated at design stages in order to improve user engagement and response (de Sousa Borges et al., 2014). Therefore, the assessment of emotional reactions should be included within the methodology itself to gauge emotional response during game-play and improve motivation and player cooperation (Anolli et al., 2010).

The development of game-based methodologies has focused on integrating three critical skills: problem-solving, teamwork, and decision-making. They were designed to support personalised learning, as games can adapt to the skill level of each learner, providing individual feedback and adjusting difficulty. As a result, GBL has been recognized as an innovative and effective learning method that aligns well with the needs and preferences of modern learners (Pacheco-Velazquez et al., 2024). For instance, Shute and Ke (2012) outline how games can assess higher-order thinking skills such as problem-solving and critical thinking through engaging mechanics. Similarly, (Landers & Sanchez, 2022) argue that GBA provides a robust framework for assessing both hard and soft skills in varied contexts. Other evidence from technology-enhanced learning studies shows that using blended learning with gamification methodologies in the form of GBL helped to reduce and overcome the technology-related fears of older adults (Koivisto & Malik, 2021; Kopeć et al., 2017). In that context, learning digital skills through gaming on a touchscreen tablet was found to be a promising and pleasant way to adopt the advantages of modern technology by older adults (Blažič & Blažič, 2020). The common property of all these approaches is the provision of a comfortable atmosphere and training support that enhances older adult' self-confidence, leading to significant improvement in adoption and engagement with digital technologies.

In current research, different GBA design approaches are explored, yet all share three major elements in GBA-based game development: the integration of cognitive and aptitude skills, attention to emotional intelligence, and user personality (Landers & Sanchez, 2022). Examples in the literature show a wide range of GBA complexities: some are straightforward, while others, such as the collaborative simulation approach, are more complex (Dubbels, 2013). Recently, GBA solutions have also gained popularity in workplace settings, where the use of serious games (designed for a purpose other than for pure entertainment) are being applied as important evaluation tools. Thus, it becomes important for game developers to comprehend how players react when playing games, how game-based learning scenarios and elements function, and what emotional states are affected by immersion in the game world (al-Qallawi & Raghavan, 2022).

Despite the growing body of work on GBA and game-based learning, limited studies specifically address the application of these methods to older populations. Much of the current research focuses on younger demographics or general adult learners. This study contributes to filling this gap by evaluating a game-based approach, DiGiUP, designed explicitly for older adults. By leveraging the DigComp framework and integrating collaborative and adaptive learning elements, this research provides insights into the efficacy of game-based methods in promoting digital inclusion for older adults and bridging the existing digital divide.

4. METHODOLOGY

The combination of the applied GBA approach, followed by the gamified training was based on the selected competence areas from the DigComp 2.2 framework. From the five main areas presented as a digital competence framework for citizens, three were considered as the essential game elements: *Information and data literacy, Safety,* and *Problem solving* (see Figure 1). Each of the three selected competence areas contains several activities that have been introduced in the game in order to enable learning and assessment. As pointed out in Section 2, the specification of the game elements follows the MDA design framework (Hunicke et al., 2004). The game is therefore described through these properties (in Section 3.3) to facilitate the understanding of both the development and the flow of game play. The result is the design and development of a game-based approach, DiGiUP (Digital Upskill), that allows for assessment and improvement of digital competencies. The game is intended to facilitate the training of older adults' digital skills by making them more confident and successful in acquiring their digital competencies, while allowing for evaluation of players' digital skills and knowledge. The platform that enabled the development, testing and validation of our approach was the Erasmus+ project DIGIBLEND. This led to an evidence-based methodology that is reusable and testable by other researchers and practitioners.

DiGiUP has the shape and properties of a board game that guides the players along a predefined learning path. It was designed as an analog type with the use of playing cards. This type of playing enables the game to run as a step-by-step process, where each step is equipped with a learning material of selected digital knowledge. The use of playing cards bring to players the needed comfort and familiarity, reminding them to the playing of known card games.

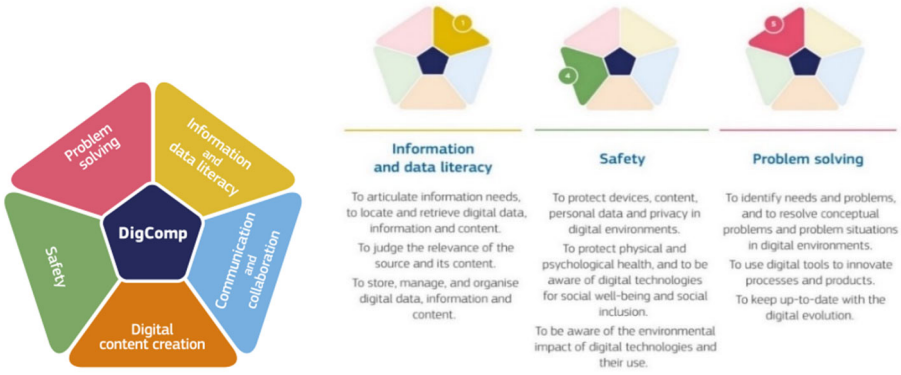


Figure 1. The three DigComp 2.2 competence areas relevant for our work

4.1 Target Group and Research Questions

To ensure successful teaching of the basic digital competencies, it was necessary to assess and acknowledge the needs and abilities of the group of older adults that will play the game. The target group that took part during the game design was clearly defined in terms of the age (65+) and the presence of "common" general educational level. As digital competencies among the members of a group vary, the first challenge in the game development was determining the

digital proficiency levels of group members. Besides information on age and the existence of some competencies, important issues that were explored were the game mechanics (rules, challenges, competitions, rewards) and dynamics (narratives, storylines). Specification about the real-time actions allowed to the learners' and the behaviors stemming from players' key decisions during the game-specific events were specified and collected. The game aesthetics was also critical and its evolution was also observed during and after the play.

The major research questions we aimed to address during game design and testing are:

- **RQ1**: Does a game-based approach allow for learning new digital competencies for older adults?
- **RQ2**: Is a game-based approach a viable method for digital competence assessment?
- **RQ3**: Does a game-based approach offer a reusable method for digital competence assessment and learning?

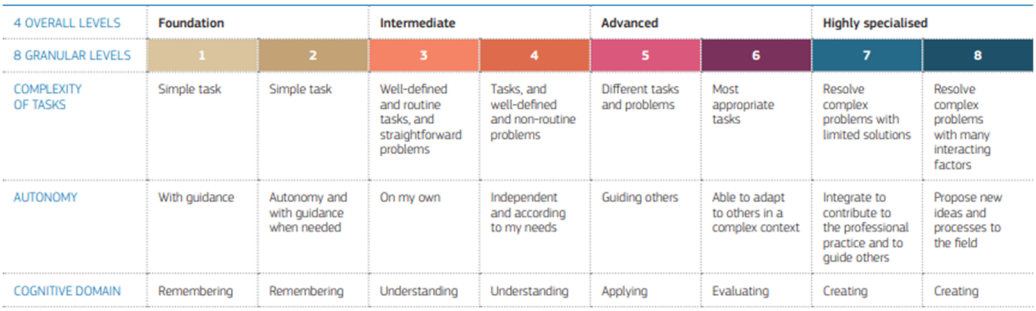
4.2 Data Collection and Analysis

Data collection and analysis were carried out to evaluate the effectiveness of DiGiUP in assessing and improving digital competencies of older adults. The testing involved 45 older adults (34 males and 11 females) between 65-78, recruited from three daycare centers in Slovenia in the period April-July 2024. The game involved 4 sessions, with four players per session, each lasting approximately 65 minutes. First, trainers informed prospective participants of the purpose and structure of testing sessions. We then obtained consent for participation from each of them, including ethical and privacy statements for the used methods, the processing of personal data, and the publishing of the processed data and results. A template of the consent form used is provided in Appendix A1.

Data were collected during game sessions and through pre/post-game evaluations, incorporating both observational and self-reported methods. Participants engaged in structured gameplay sessions moderated by trainers (game masters), who ensured smooth game flow and verified participants' actions and answers. Trainers observed participant behavior, noting levels of engagement, interaction, and progression through game sessions.

For each game, participants completed a Gameplay Questionnaire (GPQ) based on the self-determination theory (SDT) (Ryan et al., 2006). SDT highlights three core psychological needs – *autonomy, competence,* and *relatedness* – that games can fulfil. *Autonomy* implies that older adults can make choices within the game and adjust their experience to their comfort level. *Competence* means that there are opportunities to develop and demonstrate mastery of tasks during the game play, where *relatedness* signifies that a game can foster collaboration, which, in turn reduces the feeling of social isolation while promoting mutual learning. The collected data and GPQ metrics provided insights into the strengths and areas for improvement for both games. By obtaining such insights from the participants, we were to evaluate not only the effectiveness of the game-based approaches, but also their acceptance among the participants and possibilities for improvements on more specific aspects.

For the quantitative assessment of digital competencies and for determining proficiency levels, we employed the DigComp 2.2 framework, shown in Figure 2. As discussed earlier, we focus on the three areas of digital competence: Information and data literacy, Safety, and Problem solving. Each area includes specific competences, and each competence was broken down into 8 proficiency levels, organized into 4 main stages: Foundation, Intermediate, Advanced, and Highly specialized.



4 OVERALL LEVELS	Foundation		Intermediate		Advanced		Highly specialised	
8 GRANULAR LEVELS	1	2	3	4	5	6	7	8
COMPLEXITY OF TASKS	Simple task	Simple task	Well-defined and routine tasks, and straightforward problems	Tasks, and well-defined and non-routine problems	Different tasks and problems	Most appropriate tasks	Resolve complex problems with limited solutions	Resolve complex problems with many interacting factors
AUTONOMY	With guidance	Autonomy and with guidance when needed	On my own	Independent and according to my needs	Guiding others	Able to adapt to others in a complex context	Integrate to contribute to the professional practice and to guide others	Propose new ideas and processes to the field
COGNITIVE DOMAIN	Remembering	Remembering	Understanding	Understanding	Applying	Evaluating	Creating	Creating

Figure 2. The DigComp 2.2. proficiency levels

We categorized each question and task according to the DigComp competence it addresses, and aligned its difficulty with a specific proficiency level descriptor. Table 1 shows an example of this mapping:

Table 1. Mapping questions/tasks to DigComp 2.2 proficiency levels

Game Task	DigComp Area	Competence	Proficiency Level	Justification
Identify a secure password	Safety	Protecting devices and content	Level 2 - Foundation	Recognizes and applies safe password practices with support
Evaluate an email for phishing	Safety	Protecting personal data and privacy	Level 3 - Intermediate	Can recognize suspicious content and knows basic prevention strategies
Search for a recipe online	Information and data literacy	Browsing, searching and filtering data	Level 2 - Foundation	Can conduct basic searches with some assistance
Download and install a mobile app	Problem solving	Solving technical problems	Level 3 - Intermediate	Can complete straightforward installation tasks independently
Use QR codes to access learning material	Problem solving	Identifying needs and technological responses	Level 3 - Intermediate	Can select appropriate tools to access information

After mapping the tasks and questions, we tracked which level-specific tasks the players succeed at during gameplay, and then created a proficiency profile for each player. An example of this is shown in

Table *2*. This enabled us to determine the number of participants that have advanced their proficiency level in a specific area and, moreover, the progression before and after gameplay.

Table 2. Proficiency profile per player

Player	Info & data literacy	Safety	Problem solving
1	Level 1	Level 2	Level 2
2	Level 2	Level 1	Level 2
3	Level 1	Level 1	Level 2
4	Level 3	Level 3	Level 3
5	Level 2	Level 1	Level 2
6	Level 1	Level 2	Level 1
…	…	…	…

In addition to quantitative analysis, trainers provided qualitative feedback, including anecdotal evidence on how participants adapted to the games and overcame initial hesitations (see Appendix 2). Trainers' notes and participant feedback were coded and analyzed for recurring themes, such as engagement, collaboration, and the impact of game mechanics on learning outcomes. Their observations were critical in evaluating the games' ability to reduce participants' anxiety and encourage collaboration. Moreover, they noted down the participants' statements and reactions to the games, during and post-gameplay. Specific anecdotes highlighted how personalized guidance and familiar game formats helped alleviate participants' initial apprehensions.

4.3 Game Development and Description

DiGiUP delivers an engaging, educational, and collaborative experience through narrative-driven gameplay, providing players with meaningful learning process on topics related to *information and data literacy, safety* and *problem solving*. To provide a systematic outlook of the game elements and the learning process, Table 3 maps DiGiUP's elements onto the MDA framework.

Table 3. The DiGiUP game mapped onto the MDA framework

MDA Framework	DiGiUP Game elements	
Mechanics	*Game-board design*	• A house with 6 rooms (levels): Kitchen, Bathroom, Dining Room, Living Room, Bedroom, and Study Room. • Game-board size is 60 × 90 cm, players progress upward to the top of the house. • Each room contains: 4 question fields and 1 QR field for solving a digital task.
	Player components	• Colored game totems (red, blue, green, yellow) to track individual progress.

		• Help tiles (12 total), also called trading cards, for assistance during challenges. • Bridging cards (24 total) to "bridge gaps" in knowledge through learning modules.
	Question system	• Questions are categorized by difficulty levels: basic, intermediate, and advanced. • A question book managed by the game master provides quiz content tied to digital competencies in information literacy, safety, and problem-solving.
	Winning conditions	• Players complete all six rooms by answering questions and solving digital tasks. • The first player to reach the top wins, with tiebreakers based on the lowest number of unused bridging cards or a dice roll.
Dynamics	*Progression through levels*	Players answer questions to advance through each room. At the end of a room, they face a mandatory digital task at the elevator to move to the next level.
	Strategic use of help tiles and Bridging cards	• Players use help tiles to 1) request assistance or 2) exchange for bridging cards. • Bridging cards provide access to additional learning modules, enabling players to acquire the knowledge needed to answer difficult questions.
	Collab. problem-solving	Help tiles promote teamwork by encouraging players to assist each other in answering questions or solving digital tasks.
	Player-driven difficulty	Players can choose the level of difficulty for each question, allowing them to tailor challenges to their skill level.
	Competition for progress	Limited help tiles and the scoring system for bridging cards introduce strategic decision-making.
Aesthetics	*Narrative immersion*	• The story revolves around proving digital competency to take care of grandchildren, providing players with a relatable and motivating context. • The narrative creates a sense of purpose as players navigate the rooms and challenges of the house.
	Challenge and mastery	Players face increasing difficulty through the progression of questions and digital tasks, fostering a sense of accomplishment as they overcome each level.
	Collaborative learning	The integration of help tiles and bridging cards encourages teamwork and shared learning, making the experience both interactive and supportive.
	Customizability and inclusivity	The game accommodates varying skill levels through adjustable question difficulties, ensuring accessibility for diverse participants.
	Rewarding learning	Bridging cards transform incorrect answers into opportunities for learning, reinforcing educational goals.
	Competition and strategy	The race to the top of the house creates a sense of excitement and rivalry, while resource management adds a layer of strategic depth.

In DiGiUP, players take on the role of trusted community members participating in a digital discovery challenge: *The local community center has launched a month-long initiative to promote smart, safe, and confident use of digital tools for everyday tasks, from staying*

connected with loved ones to managing appointments, online shopping, and ensuring digital safety. As participants, players move through familiar settings like the kitchen, living room, and study, solving practical digital challenges tailored to real-life situations. Their mission is to complete tasks, gain confidence, and unlock digital milestones that support independence and lifelong learning.

The game unfolds in a house represented on the game board, featuring six distinct rooms, as shown in Figure 3: Kitchen, Bathroom, Dining Room, Living Room, Bedroom, and Study Room.

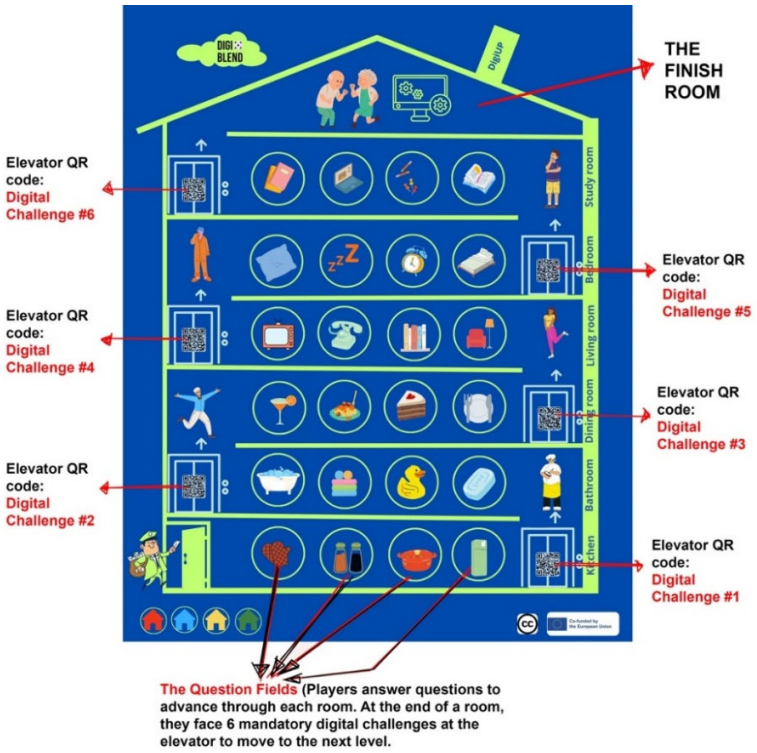


Figure 3. The DiGiUP game board design

Each room corresponds to a specific set of digital competencies from the DigComp 2.2 framework, with, for instance, the Kitchen and Living Room focusing on Information and data literacy, and the Bathroom and Bedroom emphasizing Safety skills. The narrative progresses as players move from room to room, starting at the bottom of the house and advancing upwards toward the top floor. To begin, each player selects a totem to represent their progress. Players take turns entering each room and tackling its challenges, which consist of four quiz-style questions (the “traditional steps”) and a final digital task (the “digital step”). The questions vary in difficulty from basic, through intermediate, to advanced level. They are presented by the game master, who uses a booklet containing quizzes tailored to each room's topic. Players must choose the difficulty level of each question based on their confidence and strategy.

As players encounter questions, they have the option to answer independently or rely on game resources for assistance:

- If they answer correctly without aid, they progress to the next question and retain any unused help tiles.
- If they struggle, they can use a help tile to request assistance from another player or exchange it for a bridging card.

The bridging cards (see Figure 4) act as powerful learning tools, offering access to relevant learning modules via QR codes. By scanning the code, players are directed to an online resource that helps them build the knowledge needed to answer the question.

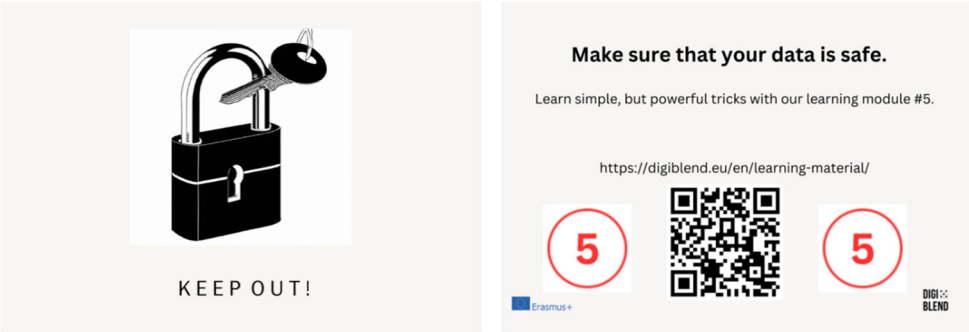


Figure 4. The Bridging card no.5: the front and the back side

Each room culminates in a mandatory digital task at the elevator (represented by a QR field). Only after successfully completing this task can players proceed to the next room. These digital tasks test practical skills aligned with the room's theme, reinforcing learning through application. Players who answer all questions and complete the digital task advance, continuing their journey toward the top of the house.

The game's competitive edge comes to life as players strive to reach the final room. The first player to complete all six rooms and solve the last digital task wins. In the case of a tie, the winner is determined by the number of unused bridging cards – rewarding efficient problem-solving and self-reliance. If still tied, a dice roll will ultimate resolve the competition.

DiGiUP combines storytelling, strategic decision-making, and collaborative learning, creating an engaging experience that not only evaluates but actively enhances digital skills. Through the use of bridging cards, customizable question difficulties, and interactive digital tasks, the game ensures meaningful learning outcomes while fostering a sense of challenge, collaboration, and achievement.

Each room culminates in a mandatory digital task at the elevator (represented by a QR field). Only after successfully completing this task can players proceed to the next room. These digital tasks test practical skills aligned with the room's theme, reinforcing learning through application. Players who answer all questions and complete the digital task advance, continuing their journey toward the top of the house. The game's competitive edge comes to life as players strive to reach the final room. The first player to complete all six rooms and solve the last digital task wins. In the case of a tie, the winner is determined by the number of unused bridging cards – rewarding efficient problem-solving and self-reliance. If still tied, a dice roll will ultimate resolve the competition. Such use of bridging cards, customizable question difficulties, and interactive digital tasks, ensures meaningful learning outcomes while fostering a sense of challenge, collaboration, and achievement.

5. RESULTS AND ANALYSIS

DiGiUP provided an engaging and interactive learning experience, yielding valuable insights into players' acquired skills, as well as on its impact on the participants experience (see Figure 5). Trainers, who were responsible for facilitating the game's progression, noted that the gameplay effectively stimulated learning and cooperation among players (refer to Appendix A2). This was accompanied by an enhanced sense of curiosity, as participants expressed excitement about discovering "what's next" during each stage of the game. Players particularly appreciated the dynamic elements of the game, including the digital challenges and tasks, as well as the incorporation of peer-learning experiences that fostered collaboration. Participants appeared comfortable during each game session. Moreover, playing encouraged discussions and meaningful interactions among players, making the experience immersive and engaging.

Figure 5. The testing session of the DiGiUP game

Following each session, participants completed a multiple-choice questionnaire to assess their perceptions and learning outcomes. The results, summarized in Figure 6, reveal that majority of players (63%) felt more confident in their knowledge and competencies after playing. This indicates that the game successfully enhanced participants' perception of their digital skills. The most notable improvement was observed in the area of problem-solving, where they demonstrated high gains in competence compared to pre-gaming evaluations. However, improvements in information safety and data literacy were modest. One reason for this is that these areas may require more immersive, real-world simulations, such as identifying phishing emails, cross-checking news sources. Hence, these areas might require additional focus or reinforcement in future iterations of the game. Overall, the fact that 72% of participants reported feeling more confident in their overall digital skills after playing the game testifies of the game's success in achieving its goals.

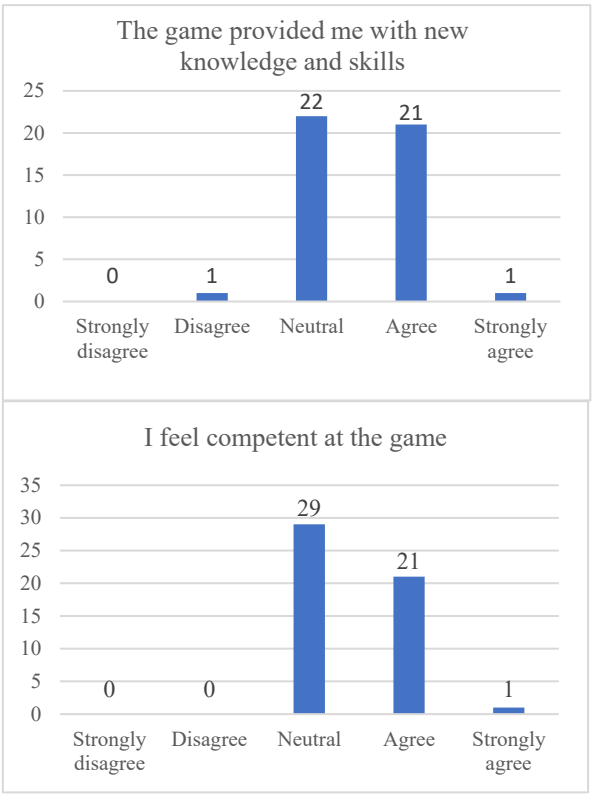


Figure 6. Data from the post-experiment questionnaire of DiGiUP game

Finally, in terms of replayability, the DiGiUP game received strong positive feedback. A total of 67% of players indicated they would choose to play the game again in their free time, highlighting its potential as a sustainable and enjoyable tool.

The qualitative analysis of the results is further supported by anecdotal evidence, observations, and trainers' notes, provided in Appendix A2.

5.1 DiGiUP Game-Based Assessment

To quantitatively assess changes in digital competence, we administered a pre/post-test based on the DigComp 2.2 framework. Each test contained 12 tasks mapped to specific DigComp proficiency descriptors across the three competence areas. The same structure was used for both tests, ensuring comparable difficulty and scope. Performance was scored and translated into proficiency levels, enabling us to track general and individual progression. Statistical analysis was performed using paired t-tests to determine significance in skill acquisition.

The clustered column chart on Figure 7 illustrates how the number of participants varied across the four DigComp proficiency levels (1 to 4) before and after playing DiGiUP, across the three competence areas: Information and data literacy, Safety, and Problem solving. There is a clear upward shift in levels, with a visible reduction in the number of participants at Level 1 across all areas post-test. Conversely, there's a marked increase in the number of participants at

Levels 3 and 4, indicating significant skill development. More specifically, for Information and data literacy, pre-test results were concentrated in Levels 1 and 2, whereas post-test shows that most participants fall into Level 3, with a notable rise in Level 4 as well. For Safety, participants initially demonstrated low to moderate skills (mostly Levels 1 and 2). Post-gameplay, the distribution shifted, with many moving into Level 3, although fewer reached Level 4 compared to the other areas, indicating that Safety may require further reinforcement. Finally, Problem solving showed the most dramatic improvement. The number of participants in Level 3 and 4 increased significantly post-test, reflecting a strong impact of gameplay on applied digital problem-solving skills.

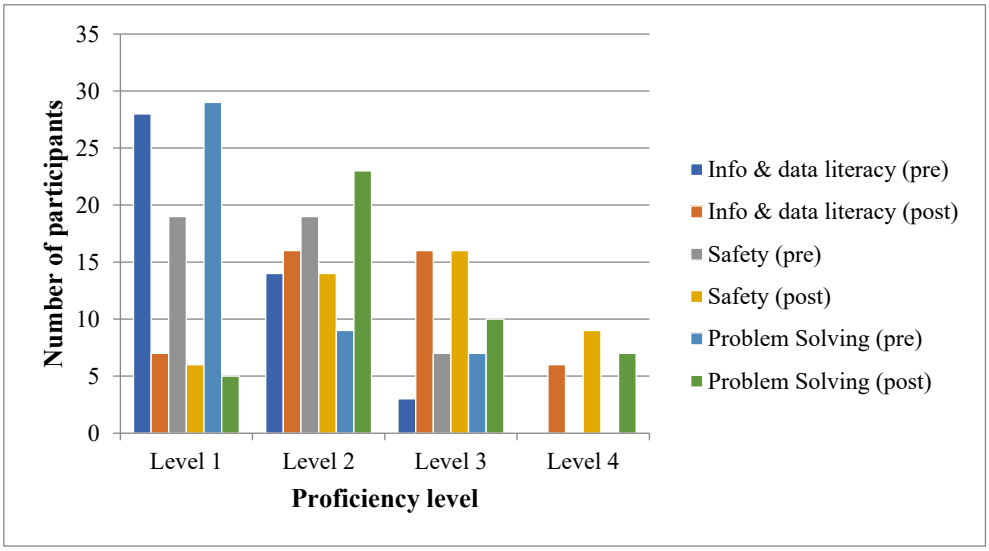


Figure 7. DiGiUP proficiency level pre/post-test distribution

The line chart on Figure 8 plots the average (mean) proficiency scores before and after the DiGiUP intervention across the three competence areas. Notably, mean scores increased in all areas: Information and data literacy improved from approximately Level 1.9 to Level 3.0; Safety rose from Level 1.8 to Level 2.9, still showing a slightly lower gain compared to the others; whereas Problem solving increased from Level 2.0 to Level 3.2, confirming this was the area with the greatest mean improvement.

All three areas follow a similar pattern, demonstrating that DiGiUP effectively enhances a broad range of digital competences, not just isolated skill sets. The results suggest that after gameplay, many participants advanced from foundational digital competence (Levels 1–2) to intermediate or advanced foundational levels (Levels 3–4), indicating progress toward bridging the digital divide. These findings reinforce the educational effectiveness of DiGiUP's game-based learning approach: the mechanics encouraged repeated engagement and exploration in a non-threatening environment; scenario-based tasks mimicked real-world digital challenges, aiding in practical skill transfer; and gains in problem solving suggest that DiGiUP promotes digital autonomy and confidence, which are the key traits for older adults facing a digital society.

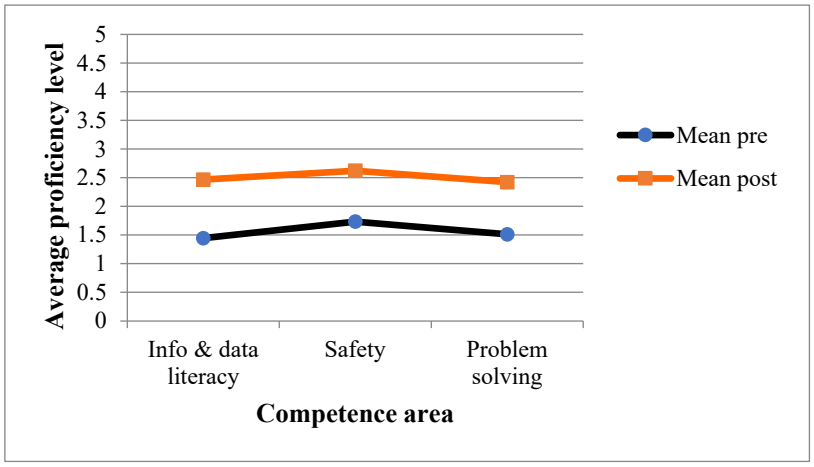


Figure 8. Mean proficiency levels (pre/post testing)

5.2 Discussion

The testing provided valuable insights into the properties and effectiveness of DiGiUP. The findings reaffirm GBA's and GBL's the potential as valuable methods for assessing and improving digital competencies of older adults. The results showed noticeable improvements in participants' digital skills across all competence areas, particularly in the area of Problem solving. However, the complexity and longer duration of the game posed challenges. Some participants found it too long and occasionally difficult to follow, suggesting a need for simplified rules and shorter sessions to sustain focus and accessibility.

An important point is the critical role that trainers played in ensuring the success of the gameplay. They guided participants, tracked their progress, and tailored the experience to individual needs. Over successive sessions, trainers reported needing less intervention, highlighting the games' effectiveness in building participants' confidence and competence. Clearly, the trainer's skill and game understanding can impact the learning effectiveness of DiGiUP. A training program is thus an important part of the pre-learning.

The results and observations allowed us to address the study's research questions: **(RQ1)** The results demonstrated that the game effectively assessed and improved digital competencies, offering participants a clear understanding of their skills; **(RQ2)** The game facilitated skill development across all competence areas, particularly in Problem solving, while fostering confidence and curiosity; and **(RQ3)** The game proved to be a reusable tool, adaptable to various learning needs and capable of providing engaging and educational experiences over multiple sessions. The analysis yielded several recommendations to enhance future use:

1. **Simplify mechanics and structure** with rules that are straightforward, ensuring accessibility for participants with varying levels of initial knowledge and skills. Moreover, sessions should be broken into more manageable segments to maintain focus and engagement.
2. **Incorporate interactive and multimedia content** by adding diverse interactive elements to accommodate different learning preferences.

3. **Emphasize collaboration** by keeping peer-to-peer interaction central to the gameplay, leveraging mutual learning as a key benefit for older adults.
4. **Provide trainer support** by continuous guidance to help participants navigate the game and achieve learning outcomes.
5. **Include follow-up activities** through additional resources or sessions to help reinforcement of newly acquired skills.
6. **Train the trainers** to establish a trainer community for best practice exchange. This is especially important considering that personalized training has been proved as one of the most effective methods for learning digital skills for older adults (Pihlainen et al., 2021).
7. **Customize the game for cultural contexts** to suit different cultural and national backgrounds, ensuring relevance and inclusivity for diverse groups.

By addressing the highlighted recommendations, future iterations of these games can further enhance their accessibility, impact, and adaptability to diverse learning environments.

Aside from the promising outcomes observed in this study, some limitations must be acknowledged. First, the study did not assess long-term retention of the obtained skills. This was due to time constraints for the pilot testing at the participating day-care centers, which made follow-up sessions not feasible. As part of our future work we plan to incorporate follow-up assessments to evaluate whether participants continue to apply the skills gained, which will help assess learning retention and behavioral change over time.

Furthermore, the study included 45 older adults from three Slovenian day-care centers. While this allowed for rich, context-sensitive observation, it limits generalizability. We intend to expand testing with a larger and a more diverse sample to not only obtain more generalizable results, but also explore cultural, linguistic, and socioeconomic factors in digital learning engagement.

Finally, our work addressed three of the five areas defined in the DigComp 2.2 framework: *Information and data literacy, Safety,* and *Problem solving*. These three areas were identified as priority needs and were best suited for gamified learning within the given project scope. The next iteration of the game will also include *Communication and collaboration* and *Digital content creation*, which will offer a more comprehensive DigComp coverage and align closely with the full digital competence model.

6. CONCLUSION

In this work, we successfully developed a game-based approach named DiGiUP, with integrated digital content as learning and assessment tools of digital competencies for older adults. The testing results have shown that the game offers strong foundational framework for further iterations and improvements. By combining GBL and GBA into a blended learning approach, the game-based method offers a sociable, engaging, and low-risk way for older adults to practice digital skills while fostering self-guided learning. These factors are particularly significant for older learners, as the games provide a safe and enjoyable environment to build confidence and assess digital skills without fear of failure.

Our work has shown that DiGiUP offers a promising method to bridging the digital divide for older adults, offering an engaging way to integrate them into the digital environment and lifestyle with reduced apprehension or resistance. The findings confirm that the approach is both

effective and accessible for teaching and assessing digital competencies for this population, promoting inclusion and fostering lifelong learning in a friendly, supportive manner.

Future research will focus on improving the games' mechanics following the findings from this study, and validating the new elements by testing the games across a broader international context. Furthermore, we aim to carry out follow-up assessments to evaluate learning retention and behavioural change over time. Moreover, we aim to cover all competence areas of the DigComp 2.2 framework, adding insights for the Communication and collaboration, and Digital content creation areas to our research. These efforts aim to strengthen the foundation for policy recommendations and create specific guidelines for practitioners involved in game-based and lifelong learning initiatives.

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APPENDIX

A1. CONSENT FORM

INFORMED CONSENT FORM FOR PARTICIPANTS IN THE STUDY

Full title of the study

Improving adult digital literacy through innovative gamified blended learning

Name of Principal Investigator:

Please read the following statements carefully and circle the relevant answer below the statement.

1. I confirm that I have been informed and understand the subject information for the above study, and that I had the opportunity to ask questions and obtain sufficient information for the purpose of the experiment and my own participation in it.

YES / NO

2. I understand that my participation is voluntary and I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

YES / NO

3. I understand that information on my input in this study will be analyzed for the purpose of the project and that my personal demographic data will be used for statistical purposes without personally identifying information.

YES / NO

4. I understand that I will not be compensated financially or receive any other material benefit for my participation.

YES / NO

5. I agree to take part in this study, willfully and without any pressure.

YES / NO

_____	_____	_____
Name of participant	*Signature*	*Date and place*
_____	_____	_____
Name of person taking consent	*Signature*	*Date and place*

A2. Trainer notes and observations

Trainer Note 1: Initial engagement

"At first, many participants appeared hesitant, especially when reading the digital-themed question cards. Some whispered that they 'might not know the answer' or 'haven't used a smartphone much.' But once the dice were rolled and the physical game-board was introduced, their posture relaxed. The tactile, turn-based format seemed familiar and comforting."

Trainer Note 2: Peer learning

"One participant, who struggled with QR codes, was gently coached by her teammate. After a few rounds, she was explaining the task to someone else at the table. That shift from being unsure to becoming a helper was one of the strongest outcomes observed."

Trainer Note 3: Overcoming apprehension

"A male participant in his 70s who initially claimed he was 'too old for these digital things' later commented: 'This is actually fun. I didn't think I'd get any of this, but now I see I do know some things.' That small boost in confidence changed his attitude throughout the rest of the session."

Trainer Note 4: Humor and social bonding

"Participants often laughed when they landed on a penalty square or answered a question dramatically wrong. It turned mistakes into group learning moments. One table even started giving out 'fake awards' like 'Best Googler.'"

Trainer Note 5: Narrative-driven motivation

"The role-playing scenario—moving through a virtual house to complete digital tasks—sparked curiosity. One participant said, 'It's like we're playing a detective game in our own home.' The setting made the challenges feel personal and practical."

Trainer Note 6: Reduction in digital anxiety

"Several participants reported feeling 'less nervous' about making mistakes in DiGiUP compared to previous learning experiences. One woman said, 'Here, I can try and try again without anyone judging me. It's like a sandbox, not a test.'"

Trainer Note 7: Stronger independent problem solving

"Compared to INFINITY, more participants attempted to complete tasks without asking for help immediately. In one case, a participant who used to defer to others during gameplay said, 'Let me try first—I think I can do this one.' That was a turning point for him."

Trainer Note 8: Empowerment through success

"At the end of one session, a participant told the group: 'I managed to identify a phishing message on my own! That happened last week and I remembered what we did here.' Trainers noted visible pride and improved digital self-efficacy."

Trainer Note 9: Collaborative dynamics

"One table developed a strategy where each player would 'specialize' in a certain type of task – emails, browsing, safety tips – and they would consult each other before locking in an answer. This cooperative play deepened their learning and built trust."