DigComp Quest: A Game-Based Approach for Assessing and Enhancing Digital Competences

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Abstract. DigComp Quest is an educational game designed to evaluate users' digital competences based on the DigComp 2.2 framework. Players navigate a digital world where they control a character and interact with the environment to identify and assess their digital skills as defined by DigComp 2.2. Throughout the game, users encounter challenges tailored to the five dimensions of the DigComp 2.2 framework. The game tracks and scores their performance in each specific skill area, providing a detailed evaluation of their digital competences. Upon completing the game, an automated analysis of the user's skills is performed. Based on their interactions and performance, personalized recommendations for educational courses are offered, targeting areas where skill gaps have been identified. This approach motivates users to actively engage in learning and self-improvement. Overall, DigComp Quest creates a dynamic and enjoyable environment that combines education with entertainment, encouraging players to enhance their digital competences in an interactive and engaging way.

Keywords: Game-Based Learning, Educational Technology, Entertainment, Interactive Learning Environments, Digital Competences (DigComp 2.2), Educational Games, Digital Skills Assessment, Gamification in Education

1 Introduction

The rapid advancement of digital technology is undeniable and continues to evolve at an exponential rate, necessitating the development of digital skills for all individuals. These competences are essential for citizens to adapt to the swift progression of technology, ensuring both personal and professional growth. Digital upskilling and the ability to integrate emerging technologies are fundamental to success in today's digital landscape.

In response to these evolving demands, the European Commission has developed the Digital Competence Framework for Citizens [1], commonly known as DigComp. This comprehensive framework establishes a common language and understanding for defining and describing key areas of digital competence. The latest iteration, DigComp **2.2**, released in 2022, introduces significant updates to remain aligned with

technological advancements. Notably, it incorporates more than 250 new examples of knowledge, skills, and attitudes, addressing emerging technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and Blockchain. Additionally, it considers the interaction between digital technologies and green policies, emphasizing sustainability.

The DigComp 2.2 framework is structured around five core dimensions, each encompassing specific competences that are crucial for fostering digital literacy:

1. Information and Data Literacy
    - Identifying information needs and efficiently retrieving digital data, information, and content.
    - Evaluating the credibility and reliability of sources and their content.
    - Organizing, managing, and securely storing digital information and data.
2. Communication and Collaboration
    - Interacting, communicating, and collaborating through digital technologies with an awareness of cultural and generational diversity.
    - Participating in society through public and private digital services and participatory citizenship.
    - Managing one's digital presence, identity, and reputation.
3. Digital Content Creation
    - Creating and editing digital content in various formats.
    - Integrating and re-elaborating digital content while understanding copyright and licenses.
    - Programming and giving understandable instructions to computing systems.
4. Safety
    - Protecting devices, content, personal data, and privacy in digital environments.
    - Safeguarding physical and mental well-being, being aware of digital technologies' impact on social inclusion.
    - Understanding the environmental impact of digital technologies and their use.
5. Problem-Solving
    - Identifying needs and conceptualizing digital solutions.
    - Using digital tools to innovate processes and products.
    - Keeping abreast of digital evolution and staying informed about technological advancements.

These dimensions collectively provide a structured approach to understanding and developing digital competences, ensuring individuals are equipped to navigate the complexities of the digital world.

Serious games—games designed for purposes beyond mere entertainment—have emerged as effective tools for refining and cultivating digital competences. By integrating educational content into engaging and interactive experiences, serious games offer several advantages:

- Experiential Learning: Players actively engage in scenarios that require the application of digital skills, facilitating hands-on learning and retention.
- Immediate Feedback: These games provide instant feedback on decisions and actions, allowing learners to understand and correct mistakes in real-time.
- Motivation and Engagement: The immersive nature of games enhances motivation, encouraging continuous learning and practice.
- Safe Environment: Learners can experiment and take risks without real-world consequences, fostering confidence in applying digital skills.

Incorporating serious games into educational and training programs aligns with the DigComp 2.2 framework by providing practical contexts in which individuals can develop and demonstrate competences across its five dimensions. For instance, simulation games can enhance problem-solving skills by presenting complex digital challenges, while collaborative games can improve communication and teamwork abilities in virtual environments.

A thorough understanding of the DigComp 2.2 framework enables a deeper exploration of its applications and benefits in education and professional development. By integrating serious games into training methodologies, individuals and organizations can effectively enhance digital literacy, drive innovation, and adapt to the ever-changing technological landscape. This approach not only makes learning more engaging but also ensures that the acquisition of digital competences is aligned with real-world applications, ultimately fostering greater societal and economic progress.

This study introduces DigComp Quest, a serious game designed to assess and enhance users' digital competences across the five core dimensions outlined in the European Commission's Digital Competence Framework for Citizens. The game immerses players in a digital world featuring various mini-games, each targeting different combinations of these dimensions. Upon completion, DigComp Quest evaluates the user's competences, providing individual scores for each dimension along with tailored learning materials to facilitate improvement in all five areas.

2 Related Work

The integration of serious games and gamification into educational frameworks has been increasingly recognized as an effective strategy for assessing and enhancing digital competences. Research in this domain underscores the potential of these interactive approaches to foster essential digital skills across various educational contexts.

A notable study by [2] explores the role of gamification in developing digital competence among higher education students. The authors analyze the components of digital competence as defined by the DigComp 2.0 framework and examine how gamification principles can be effectively applied to cultivate these skills. Their case study on the implementation of the PC Building Simulator in an Informatics course demonstrates how gamified approaches can address multiple dimensions of digital competence development, suggesting that thoughtfully designed gamification strategies can significantly enhance student engagement and systematically develop crucial digital competences required in the modern professional landscape.

Similarly, Eliana Vanessa Collantes Robles[3] investigates the effect of gamification on the development of digital competences among basic education teachers in Trujillo, Peru. Utilizing a quasi-experimental design, the study reveals significant improvements in teachers' digital competences across all dimensions—information literacy, communication, content creation, safety, and problem-solving—following participation in a gamified training program. These findings suggest that gamification is an effective strategy for developing educators' digital competences, offering valuable insights for teacher training and education policies.

Further, another study [4] discusses the development of students' skills through gamification and serious games. The research highlights the close relationship between serious games and gamification tools and their potential in educational settings. It emphasizes that thoughtfully designed gamification approaches can significantly enhance students' motivation and engagement while systematically developing crucial digital competences required in the modern professional landscape.

Collectively, these studies underscore the efficacy of serious games and gamification as dynamic tools for assessing and developing digital competences, highlighting their versatility and effectiveness across diverse educational settings.

3 Methodology

The development of the game, its implementation, the theoretical foundation of this thesis, and the final composition necessitated extensive research to identify appropriate tools and conduct a thorough literature review. The research methodology was informed by the DigComp framework, its official website, and examples provided by the Unity game development engine. Additionally, the internet played a crucial role in seeking solutions to questions and challenges encountered during the development process.

The primary engine employed for game development was Unity, a widely acclaimed and robust platform supporting both 2D and 3D environments. Unity facilitates development through the use of the C# programming language, renowned for its user-friendliness and flexibility in software development. One of Unity's primary advantages is its intuitive user interface, complemented by an extensive library of additional tools and resources. This repository allows developers to address most requirements during game development, offering solutions that streamline the creation process. The company behind Unity is committed to the continuous improvement of the software, providing regular updates to ensure the platform remains at the forefront of technology. Another significant feature of Unity is its availability as a free download for personal use, making it an economically viable option for academic projects. Lastly, the abundance of information and educational materials available online greatly facilitates the learning curve associated with using Unity, offering support and guidance when questions or challenges arise during game development.

Furthermore, the image editing application GIMP 2.10 was utilized. Collectively, these tools and technologies were instrumental in successfully achieving the objectives

of this project as many of the assets of the game needed to be either created or edited to be presented in it.

The game's design leveraged the DigComp framework, which offers valuable insights for developing educational games. This process involved implementing the game's logic by developing a main scene and incorporating multiple challenges, known as mini-games, to meet users' educational needs. After defining the central concept and the mini-games with which users would interact, the next step was designing the environment to explore how to realize these ideas.

The mini-games were designed as standalone modules, requiring considerable time and effort to achieve an aesthetically pleasing yet straightforward form, ensuring accessibility for users with varying skills and gaming experience. To create the primary environment in the main scene, a tutorial from the Unity platform was utilized, aiding in understanding the development environment's functionality and initiating the creation process, given that its use was non-commercial, aligning with the project's academic nature.

Subsequently, the implementation of the mini-games commenced, presenting several challenges, such as the difficulty in locating suitable images and assets. This necessitated either creating the required graphics from scratch or seeking alternative solutions that met the game's requirements. Finally, the testing and optimization phase was crucial to ensure the game operated smoothly, free from errors and issues that could negatively impact the user experience. For additional evaluation, assistance was sought from various peers who were provided with the game for testing. They were asked to offer feedback and suggestions for potential changes that might have been overlooked due to the developer's close involvement in the development process.

4 System Design and Implementation

4.1 Game Architecture

DigComp Quest is a computer-based educational game developed with a straightforward structure to accommodate users with varying levels of experience in interacting with computers and games. The development primarily utilized the Unity engine, supplemented by various packages and assets from the Unity Asset Store to enhance functionality and user experience.

Key resources incorporated into the project include:

- 2D Packages: These tools facilitated the creation of a versatile two-dimensional environment, offering flexibility and creativity in design.
- Addressables Package: This package streamlined the management of images and other assets by assigning unique addresses, enabling efficient access from any point within the game.
- TextMeshPro: This tool enhanced text rendering, providing more visually appealing and professional results compared to Unity's default text system.

- Unity Learn | 2D Beginner: Tutorial Resources | URP: Initially used for foundational learning, this asset was instrumental in shaping the game's initial environment and understanding core principles of game development.

The integration of these resources was pivotal in achieving the educational objectives of DigComp Quest, ensuring an engaging and accessible experience for all users.

The game features a main menu scene with three buttons: "Start Game," "Options," and "Exit." Upon selecting "Start Game," the user enters the main scene, which presents an environment containing the user's avatar and a non-player character (NPC) who guides the user on how to play. Interacting with the environment triggers various mini-games, including multiple-choice questions, jigsaw puzzles, matching games, and image-based true or false challenges. (Details on the implementation and mechanics of each mini-game will be provided later.) After completing all the mini-games, a results scene displays the user's assessment and offers learning materials to enhance proficiency in each dimension. Additionally, a text file containing this information is saved to the user's desktop for future reference.

4.2 Game Mechanics

The game, as previously mentioned, consists of a main scene where the user interacts with the environment and initiates various mini-games. Each mini-game is unique, culminating in a results scene where the user receives feedback and access to learning materials.

The main scene (Figure 1) features the user's avatar, a fox, alongside a non-playable character (NPC), a frog, and numerous pylons scattered throughout. Interacting with these pylons triggers different mini-games. Users can navigate the environment using both the WASD keys and the arrow keys, which are standard controls in the gaming industry, ensuring familiarity for players. As the user moves closer to a pylon or the NPC, a dialog box appears, providing instructions on how to interact with the pylons and access the mini-games. The interaction key is 'E', a common choice in gaming, conveniently located near the WASD keys for easy access. Each pylon has a defined interaction range, allowing users to engage with the mini-games based on a specified interaction distance in their configuration.

Within the mini-games, users must utilize the mouse to complete tasks, as each game employs a point-and-click approach. The system monitors user performance based on correct and incorrect answers, as well as the time taken to complete each game. This data is used to calculate scores and provide meaningful feedback.

Fig. 1. Main Scene

4.3 Mini Games Design

The educational mini-games developed for this project encompass four distinct formats: multiple-choice questions, puzzles, matching exercises, and true/false questions accompanied by images. These formats were deliberately selected for their widespread recognition and efficacy in facilitating learning, ensuring accessibility for users with diverse backgrounds.

Multiple-Choice Questions (MCQs): MCQs are prevalent across various educational levels, offering a familiar assessment method that can evaluate a broad range of knowledge and cognitive skills (Fig. 2). They are efficient to administer and can effectively measure learning outcomes at almost any level.

The mini-game is quite simple. At the top, it displays a question along with four possible answers presented as buttons. The user must select one of the four buttons to submit their answer. If the answer is incorrect, the button will turn red; if correct, it will turn green. After each selection, the scene updates with a new question until all questions have been answered. Finally, the game provides the user with the total number of correct answers before returning to the main scene or result scene depending if it's the last mini game or not.

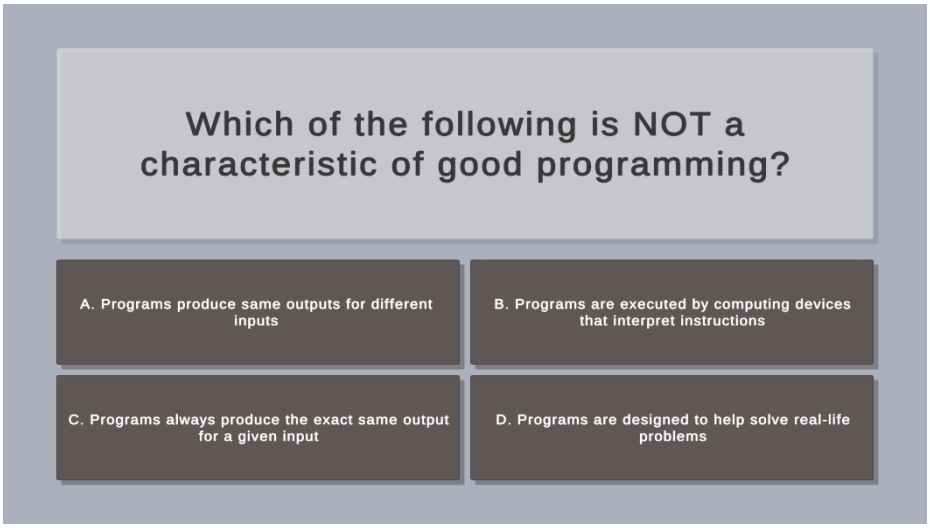

Fig. 2. Multiple-Choice Questions.

Puzzles: Incorporating puzzles into the learning process enhances problem-solving abilities, encouraging users to develop critical thinking and strategic planning skills (Fig. 3). Puzzle-based learning has been recognized for its effectiveness in building complex, transferable skills.

The mini-game is designed to be straightforward. Players click on a piece, then drag and drop it into the designated panel. This panel features a grid, with each piece having a specific correct position within it. If a player drops a piece close to its correct position, it will snap into place and become locked, preventing any further clicks. Once the puzzle is completed, the user will return to the main scene, unless it is the final mini-game, in which case they will proceed to the results scene.

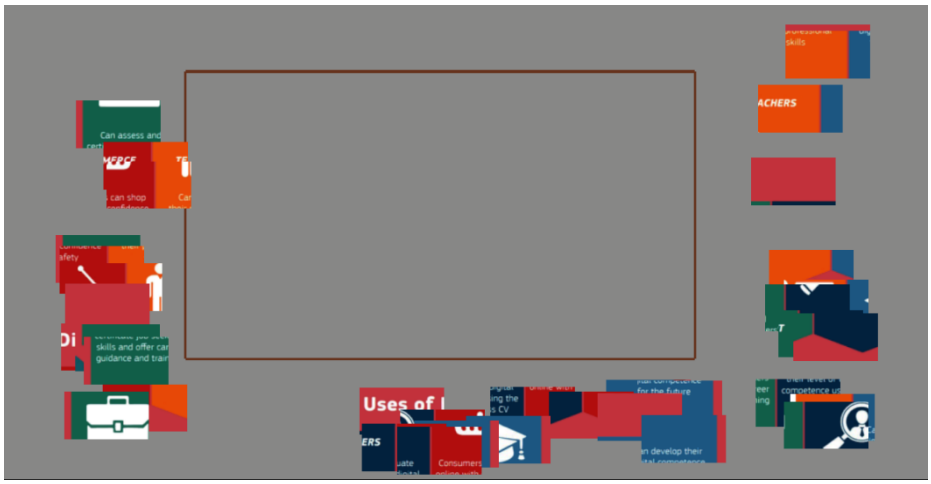

Fig. 3. Puzzles.

Matching Exercises: These activities promote the recognition of relationships between concepts, aiding in the reinforcement of memory and understanding. Matching questions are particularly beneficial for assessing the ability to identify associations and are suitable for users with varying levels of prior knowledge (Fig. 4).

The mini-game is quite simple as well, it has a side with names and a side with images. The user has to click on either the name or the image in order to match them. If the match is incorrect, both the image and the name will turn red; if it's correct, both of them will turn green. This is the only game that there is a visible scoreboard that updates with each correct or incorrect match. Once the puzzle is completed, the user will return to the main scene, unless it is the final mini-game, in which case they will proceed to the results scene.

Fig. 4. Matching Exercises.

True/False Questions with Images: This format offers a quick and effective assessment method, with the inclusion of images enhancing comprehension and engagement (Fig. 5). True/false questions are well-suited for testing recall and comprehension, and when paired with visuals, they can make the content more accessible and appealing.

The mini-game is quite simple. At the top, it displays a question along with two possible answers presented as buttons. The user must select one of the two buttons to submit their answer. If the answer is incorrect, the button will turn red; if correct, it will turn green. After each selection, the scene updates with a new question until all questions have been answered. Finally, the game provides the user with the total number of correct answers before returning to the main scene or result scene depending if it's the last mini game or not.

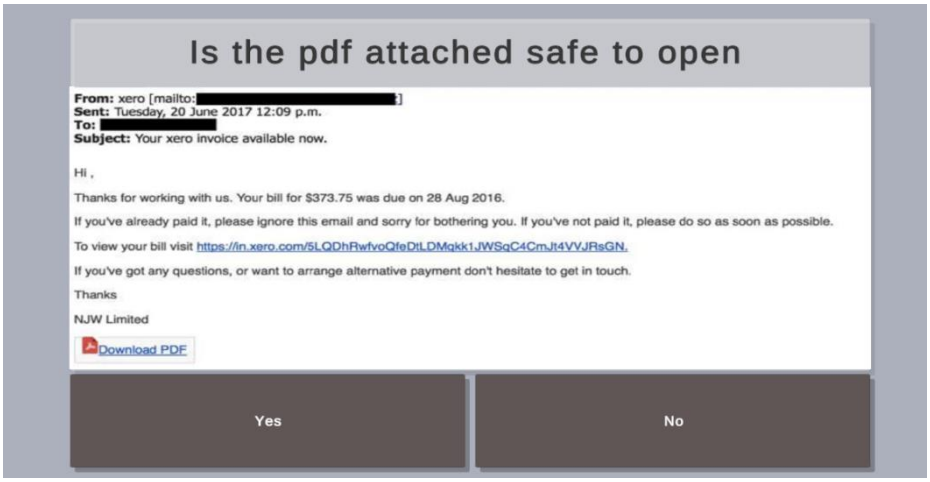

Fig. 5. True/False Questions with Images.

Collectively, these selected game formats not only enrich the learning experience but also foster user interaction and engagement, making the educational journey both enjoyable and effective.

4.4 Scoring System & Feedback

The user assessment is conducted individually within each mini-game, with all data stored in the DataManager. This system maintains separate variables for each category's score and its maximum possible value. During gameplay, as points are awarded to the user, the corresponding maximum score is also updated. At the game's conclusion, the user's performance is evaluated by calculating a percentage based on their score relative to the maximum score. This percentage determines the number of stars displayed on the results screen, effectively communicating the user's assessment.

Multiple Choice Game: In this mini-game, questions pertain to various categories, with each question tagged to a specific category. When a user answers a question, the maximum score for that category increases by one point. A correct answer also increments the user's score in that category by one point.

Puzzle Game: This mini-game is associated with a single category. The user's score is determined based on the time taken to complete the puzzle. Through testing with various individuals, a time-to-score mapping was established to evaluate user performance. Depending on the completion time, both the user's score and the category's maximum score are updated accordingly.

Matching Game: Here, scoring involves two categories with differing weights. For each correct match, the user earns 10 points, while an incorrect match results in a deduction of 5 points. At the end of the game, distinct functions for each category compute the final scores, updating the DataManager appropriately.

Image-Based True or False Game: This mini-game's evaluation mirrors that of the Multiple-Choice Game. Each question is linked to a category, and upon the user's response, both the user's score and the category's maximum score are updated.

At the end of the game, the user's overall score for each category is calculated using the formula:

$$Score = ((100*CategoryScore)/CategoryMax)/20$$

This formula yields a value between 1 and 5, facilitating the display of stars. For instance, a score up to 1 result in one star being displayed; up to 2, two stars are shown, and so forth.

Ultimately, a categorized list of learning materials will be created, tailored to scores ranging from 1 to 5. Depending on the user's score in each category, the corresponding list will be displayed in the game and included in the document.

5 Evaluation and Results

The DigComp Quest game has not yet been released for testing to gather feedback, except for a small group of individuals who participated in alpha testing and assisted me in making revisions before I submitted it as my thesis. In light of this, I will present some case studies demonstrating how my game can be utilized.

5.1 Case Study 1: Assessing Digital Competences through Gamification

A European university sought to improve students' digital competences by integrating a serious game into its digital literacy curriculum [7-9]. The game was designed in accordance with the DigComp 2.2 framework, ensuring that the mini-games aligned with all relevant competences. In the implementation phase, students engaged with a digital game that presented real-world scenarios requiring them to demonstrate their digital skills. For instance, within the Online Safety Module, players were tasked with identifying phishing emails. In the Information Retrieval Challenge, users had to search for credible sources online, while the Digital Collaboration Task simulated an online project involving file sharing and version control. Performance was monitored through in-game analytics, and players received tailored feedback based on their mistakes and achievements.

During the study, several challenges and findings emerged. Some students were initially unfamiliar with the gamified assessment method and needed guidance at the outset. In-game decision-making revealed real-world digital literacy gaps, with many students struggling to recognize misinformation. However, after participating, students reported increased confidence in online collaboration and heightened awareness of cybersecurity practices. Additionally, the game’s assessment mechanism effectively identified areas requiring further instruction.

The findings confirm that serious games offer an engaging and effective means of assessing digital competences. The ability of the game to deliver real-time feedback enhanced the interactivity of the learning experience compared to traditional methods. Based on these outcomes, universities may consider adopting similar gamified assessment tools to monitor student progress and customize digital literacy instruction accordingly.

5.2 Case Study 2: Workplace Training with Serious Games

A multinational corporation faced persistent security breaches primarily caused by employee errors, such as the use of weak passwords and a high susceptibility to phishing scams [10, 11]. Traditional training methods, including PowerPoint presentations and online quizzes, proved ineffective, as employees tended to forget the information quickly. In response, the company implemented a serious game designed around real-world cybersecurity scenarios to improve employee awareness and behavior.

During implementation, employees engaged with an interactive game that simulated various cybersecurity threats, requiring them to respond appropriately. The game included modules such as the Phishing Email Challenge, where players had to identify fraudulent emails; a Data Protection Simulation, which tasked employees with managing customer data in compliance with GDPR-like regulations; and a Password Strength Assessment that offered real-time feedback on weak password choices. The company monitored employees' in-game performance and used the results to provide targeted follow-up training tailored to individual weaknesses.

Several challenges and findings emerged throughout the process. Initially, some employees dismissed the game as trivial; however, their engagement increased notably after the introduction of competitive leaderboards. Employees who participated in the game demonstrated significantly better retention of security protocols compared to those who underwent conventional training. Furthermore, post-game surveys indicated a measurable reduction in security-related mistakes over the following six months.

The study highlighted that gamification can substantially enhance employee learning and reduce human error in cybersecurity practices. The success of the initiative suggests that organizations should consider integrating such serious games into their regular training programs to ensure continuous skill development while maintaining employee engagement.

5.3 Case Study 3: Serious Games for Elderly Digital Inclusion

A non-profit organization sought to reduce digital exclusion among elderly individuals by helping them develop essential digital skills [12, 13]. Many older adults lacked confidence in using online services such as email, online banking, and e-government portals. Traditional workshops yielded low engagement, prompting the organization to adopt a gamified learning approach. The serious game developed for this initiative included Basic Navigation Exercises, where players learned to operate a virtual smartphone interface; Online Safety Challenges, which taught participants to recognize

scams; and Email and Banking Simulations, where users practiced sending emails and making secure transactions. The game was specifically designed with accessibility in mind, incorporating large text, simple instructions, and audio guidance to accommodate the target audience.

Initially, some seniors were hesitant to engage with the game due to unfamiliarity with gaming interfaces. However, built-in tutorials and adaptive difficulty settings effectively helped bridge this gap. Following the intervention, 70% of participants reported increased confidence in using digital services, and a follow-up survey revealed that many players successfully used online banking for the first time.

This case study demonstrated that gamified learning can effectively bridge the digital divide for older adults. Accessibility and ease of use emerged as crucial factors for ensuring engagement. Policymakers and social organizations could adopt similar tools to promote digital inclusion among vulnerable populations.

Across the three case studies—university students, corporate employees, and elderly individuals—common themes emerged. Gamified methods consistently enhanced learning outcomes, leading to higher engagement and better knowledge retention compared to traditional approaches. Real-time, personalized feedback based on in-game decisions played a critical role in improving users' learning experiences. Serious games also proved valuable in identifying competency gaps, allowing for targeted interventions where users showed weaknesses. Furthermore, the success of these initiatives depended heavily on the customizability of the games, which needed to be tailored to the specific needs of each audience.

Collectively, these findings underscore the strong potential of serious games as effective tools for digital competency assessment and skill development across diverse demographic groups.

6 Discussion

DigComp Quest represents an innovative approach to leveraging gamification for assessing and enhancing users' digital competences. By integrating engaging mechanics with structured competency evaluation, the game offers a dynamic learning experience that bridges assessment and skill development.

A comparative analysis of DigComp Quest with existing systems in the literature highlights several distinct advantages. Unlike many other gamified assessment tools, which often focus on isolated aspects of digital literacy, DigComp Quest provides a comprehensive and robust framework that encompasses all key areas of digital competence outlined in the DigComp framework. This holistic approach ensures that users are not only tested on their existing knowledge but are also guided toward improvement through targeted feedback and interactive learning.

Upon reviewing existing games and applications that utilize the DigComp framework, few systems integrate it as extensively as DigComp Quest. The only notable example is DQWorld [5], which, while incorporating elements of the framework, does not fully cover all DigComp categories. This gap underscores the unique contribution of DigComp Quest, as it fills a critical void in digital competency assessment by offering a more structured, engaging, and all-encompassing learning experience.

The broader literature further validates the effectiveness of gamified approaches in enhancing core digital and cognitive skills. For instance, digital mathematical games have been shown to significantly improve technical skills among university students across diverse programs, indicating that structured game-based interventions can reinforce foundational competences that traditional methods often fail to address [14]. Similarly, the integration of adaptive mechanisms, such as learning styles and neural networks in educational games, has demonstrated strong potential in tailoring content to individual needs and optimizing knowledge acquisition [15].

Furthermore, DigComp Quest aligns with recent trends in promoting responsible digital behavior. Innovative platforms like augmented reality-based educational games have been employed to cultivate digital citizenship and ethical data practices among students [16], while immersive virtual environments with stereotype-based user models have successfully adapted scenarios to sustain engagement and improve learning outcomes [17]. These studies emphasize the growing importance of adaptability and personalization in educational game design—principles that DigComp Quest is poised to expand upon in future iterations.

It is important to acknowledge that DigComp Quest is still in its early stages of development, with significant opportunities for enhancement and expansion. Future iterations will focus on refining gameplay mechanics, expanding the range of mini-games, and incorporating more adaptive learning pathways to better tailor the experience to individual users' needs. Additionally, as digital competences continue to evolve in response to emerging technologies and societal changes, DigComp Quest will need to adapt accordingly, integrating new challenges, assessment methods, and interactive content to remain relevant and effective.

By continuously improving and expanding the game, it has the potential to become a benchmark tool for digital competency assessment and development, serving a wide range of learners across different demographics and skill levels.

7 Conclusion and Future Work

In conclusion, this paper introduces an innovative approach to assessing digital competences through gamification, providing users with a dynamic and interactive learning experience. By integrating real-time assessment mechanisms, the system not only evaluates users' proficiency across various DigComp framework domains but also delivers personalized learning materials tailored to their specific needs.

Future enhancements will focus on implementing adaptive learning pathways powered by AI-driven feedback, allowing the game to dynamically adjust difficulty levels

and suggest targeted learning resources based on user performance. Additionally, connecting the game to the internet will enable the collection of anonymized usage data for large-scale analysis, offering insights into competency gaps across different demographics. This will facilitate the optimization of mini-games, either by refining existing challenges or incorporating new ones that address underrepresented digital skills.

To achieve this, future iterations will introduce an optional user profiling feature, allowing players to input age, gender, location, and educational background. This data will enhance the game's ability to identify trends, personalize content more effectively, and contribute to broader research on digital literacy across diverse populations. Ultimately, these advancements will help ensure that DigComp Quest evolves into a comprehensive, data-driven, and scalable tool for digital competency assessment and development.

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