

Electronic, didactic and innovative platform for learning based on multimedia assets



e-DIPLOMA



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D.3.3 Gamification techniques demonstrators in e-DIPLOMA platform

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3. Introduction

3.1. Executive Summary

This work proposes a reference framework for implementing innovative gamification techniques in education, thereby fulfilling one of the specific objectives of the WP 3 of e-Diploma project: "O3.4: Establish novel methods using gamification techniques to assess student acquisition of knowledge". In line with the project's goals, gamification will be integrated through various methods commonly used in Serious Games, such as allowing users to set their own daily goals, visually displaying user progress, using external triggers to bring them back to the platform, and creating reward mechanisms for daily platform use. These elements are designed to enhance student engagement by encouraging regular interaction with the platform.

This document outlines a proposal for integrating cutting-edge and widely adopted educational gamification techniques into the e-Diploma platform, based on a thorough review of the latest state-of-the-art research. To support this integration, we first conducted a review of recent scientific literature, focusing on validated frameworks and taxonomies that guide the effective implementation of gamification projects in educational settings. Additionally, a detailed analysis of popular educational applications was carried out to examine their use of gamification techniques. Based on these studies, we selected taxonomies and dimensions that align with the e-Diploma platform's available resources and unique characteristics.

As a result, this work presents a gamification framework specifically designed for the Moodle-based e-Diploma platform. This model categorises the gamification methods explored in the literature into educational gamification perspectives tailored to meet the project's objectives. Additionally, it identifies key data sources, methods, and applications for each perspective. The framework offers a clear and concise overview of the main factors involved in implementing gamification within Moodle. First, data from various sources are collected and prepared for automation and analysis. This data includes not only logs capturing users' interactions within the Moodle Learning Management System (LMS) but also logs from external serious games utilising Virtual Reality (VR) and Augmented Reality (AR). Second, the model highlights a range of gamification methods that can be applied to the raw data. Lastly, the framework outlines potential gamification applications that can be developed and implemented in the Moodle-based e-Diploma platform.

As a main parts of the proposed framework, it is important to highlight the main contributions of our proposal:

- A framework that integrates gamification techniques to enhance student engagement and assess the knowledge acquisition process, particularly within a programming and electronics course on the LMS Moodle. The framework incorporates gamification methods validated in scientific literature. These methods have been implemented on our platform using two approaches. On one hand, we have utilised open-source tools available for the Moodle platform, some of which have been programmatically adapted to meet the specific needs of the project. On the other hand, we have developed specific methods and solutions, such as the integration and the feedback of data in Moodle with immersive Virtual Reality (VR) and Augmented Reality (AR) games.
- Specifically, we implemented a gamified virtual reality learning environment to learn and train block-based programming functions. Virtual Reality (VR) gamification is a rapidly emerging field of technology that allows users to experience virtual worlds and immersive gaming experiences (Ulmer, J. et al., 2022; Lampropoulos, G. and Kinshuk, 2024; Falah, J. et al.,2021). A numerical

feedback system using points and tracking of progress using levels are selected as key gamification elements as are two of the most frequently used motivational affordances (Legaki et al., 2020) and practical options to be integrated into existing training systems (Ulmer et al., 2020). In the proposed learning environment, a fun, motivating, and challenging activity is provided to practise the programming subjects learned in previous activities. Other gamification techniques are also included that are transversal to the dimensions defined in the framework. For example, in the “performance” perspective, data such as scores or evaluations of the knowledge acquired during the course are collected; in the “ecological” perspective, resource limitations (for example limiting programming variables or instructions) are set to reach an optimised solution, or to help students to find new paths or simple helps them to be aware of different programming points of views. The solution also addresses the “personal” perspective, as this interactive experience allows the user to progressively adapt to the game rules, to reinforce concepts and acquire knowledge, as well as offering flexibility for the user to find the solution through different pathways. The solution also incorporates the “social” perspective through a collaborative learning activity that offers various scenarios and challenges that can only be solved with two players, thereby promoting collaboration and knowledge exchange. The system also provides instant feedback to highlight any errors the user may have in the code they are programming, as well as congratulatory messages when they have done a good job. The achieved results in the virtual environment are integrated into the Moodle platform, allowing player performance to be tracked within the same platform.

The distinction between a simple gamified virtual learning environment and an integrated gamification framework within a Moodle course hinges on several key aspects. A gamified virtual environment, such as the one proposed in the e-Diploma framework, not only uses VR for teaching but fully integrates it into the learning management system (LMS), allowing for student progress to be tracked and fed back into the system. This integration means that data such as levels, points, and rewards are directly linked to the LMS's learning objectives, forming part of the student's evaluation process. Moreover, the VR environment utilizes gamification techniques like content unlocking based on student performance and personalised learning paths, linking the gameplay to the broader educational goals of the course. This helps enhance both student motivation and engagement.

Studies have shown that immersive virtual reality environments, when integrated with educational goals, offer significant benefits in terms of motivation and learning outcomes. For example, a meta-analysis found that gamification techniques, when combined with tools like VR, lead to enhanced student engagement and performance compared to traditional methods (Li, M. et al., 2023). Another review points out the importance of aligning VR-based learning environments with educational objectives to create meaningful and effective learning experiences (Hamilton, D. et al., 2021). In this way, the use of immersive technologies and gamification can significantly reinforce both the cognitive and motivational aspects of learning, making it a much more integrated and effective approach than using VR in isolation.

- On the other hand, the framework also includes an augmented reality application that integrates gamification elements. This solution features a study mode that allows users to explore the characteristics and electronic components of an Arduino board in real-time, as well as assemble various components. Additionally, the application includes a practice mode where users can test and evaluate the knowledge acquired through a knowledge quiz. The gamification elements implemented in this AR application include the use of points, progress tracking in each of the proposed activities, and two game levels or modes: the first is a quiz-based knowledge test, while the second is a practical activity for assembling Arduino boards.

- Furthermore, we addressed the integration of AI-based algorithms in Moodle with the implementation of two learning object recommender systems. To achieve this, two new block-type plugins were developed for Moodle to recommend learning objects. These recommender systems, tailored to the user experience during course progression, represent a novel approach in the scientific literature, as learning path recommendation systems adapted to Moodle's specific learning sequence have been underexplored. These types of methods constitute a gamification resource frequently advocated in the scientific literature.

Finally, the document outlines the technical steps required to configure these gamification elements and their integration with Moodle's competency-based learning system and external learning tools. The purpose of this work is to demonstrate the effective adaptation of gamification in fostering a more interactive, immersive, and rewarding educational environment, aligning with the objectives of the e-Diploma project. It is also clarified that, when examples of gamification techniques are discussed alongside implemented Virtual Reality solutions, these examples are equally applicable to the Augmented Reality tools developed. This clarification is made to avoid redundant information throughout the document. Attached to this document is a demonstration video of the proposed solution, titled *Gamification.mp4*. See link on canva.com [Gamification \(canva.com\)](#).

3.2. Relation to Other Project Documents

There is no relation with another document.

3.3. Abbreviation List

The following acronyms are frequently used in this document, listed in alphabetical order:

AR: Augmented Reality

CF: Collaborative Filtering

e-DIPLOMA: Digital Innovation for personalised Learning and Open Methodologies in Augmented and Virtual Reality

KBF: Knowledge-Based Filtering

LMS: Learning Management System

PBL: Points, Badges, and Leaderboards

VR: Virtual Reality

XP: Experience Points



3.4. Reference Documents

Indicate the reference documents (e.g., guides, book, articles, etc.) in which the present document is based on.

- D.3.4 AI Algorithms.
- D.4.2 Platform software.
- Attached to this document is a demonstration video of the proposed solution, titled *Gamification.mp4*. See link on canva.com [Gamification \(canva.com\)](https://canva.com).
- (See “References” section)

4. The Importance of Gamification in Education

The e-DIPLOMA project aims to revolutionize e-Learning by leveraging cutting-edge technologies like Virtual Reality (VR), Augmented Reality (AR), Artificial Intelligence, and gamification. One of the main goals of this project is to enhance the learning experience by incorporating engaging, interactive, and personalised elements. Gamification plays a crucial role in motivating students and improving the learning outcomes. As education continues to shift towards digital platforms, particularly due to the challenges posed by the pandemic, gamification has emerged as a powerful tool to keep students motivated and engaged in online learning environments.

Throughout this document, reference will be made to the gamification techniques and tools integrated into the e-Diploma educational platform. In addition to traditional gamification strategies, innovative elements such as Virtual Reality (VR) and Augmented Reality (AR) are incorporated through educational games, enriching the sensory experiences of students, increasing their motivation, and enhancing their understanding of the content. These disruptive technologies, while relatively new and underexplored in the current state of the art, present significant opportunities for e-learning. In the context of this project, the goal is to identify and propose best practices that maximize the potential offered by the synergy of digital technologies and the expertise of educational professionals.

4.1 What is Gamification?

Gamification refers to the application of game-design elements and principles, such as points, levels, leaderboards, and badges, in non-game contexts like education. In a learning environment, gamification aims to transform traditional educational activities into more interactive and engaging experiences by introducing rewards, challenges, and competition (Majuri et al., 2018). Gamification is designed to increase student motivation, participation, and overall satisfaction with the learning process by making education feel more like a game (Khaldi et al., 2023).

Recently, a novel approach to gamification has emerged within immersive Virtual Reality (VR) experiences in educational settings, introducing a gamified virtual reality learning environment. This approach extends traditional gamification techniques—such as points, levels, and leaderboards—into immersive environments where students are more engaged and focused. The combination of VR and gamification has been shown to enhance both the motivational and cognitive aspects of learning, offering real-time feedback, personalised learning paths, and multi-sensory interaction, which are not possible in traditional educational settings (Ulmer, J. et al., 2022; Lampropoulos, G. and Kinshuk, 2024; Falah, J. et al., 2021).

In addition, the concept of gamification has extended beyond traditional educational settings, reaching into immersive technologies like Augmented Reality (AR). In the context of education, AR has demonstrated its potential to transform learning by integrating digital elements into real-world environments. This method not only enhances students' interaction with learning content but also increases engagement and motivation. AR-based educational tools allow for hands-on activities, real-time feedback, and adaptive learning paths, which are key components of gamified experiences. By introducing points, progress tracking, and various levels of difficulty in AR environments, students can enjoy a more dynamic and interactive learning process. These innovations have found particular success in STEM education, where abstract concepts can be visualised and understood more easily through immersive AR experiences (Kao & Ruan, 2022; Theodoropoulos & Lepouras, 2021)

4.2 How Does Gamification Affect the Learning Process of Students?

Gamification has a significant impact on students' learning processes by increasing engagement, motivation, and retention. Studies have shown that gamification enhances student motivation by making learning more interactive and rewarding. For example, the work in (Jaramillo-Mediavilla et al., 2024) found that gamification positively influences academic performance by helping students assimilate knowledge more effectively, improving their skills and competencies, and fostering active participation.

Gamification techniques like points, levels, and badges encourage students to persist in their studies by providing clear goals and immediate rewards for their achievements. Additionally, leaderboards and challenges introduce a competitive element, motivating students to improve their performance relative to their peers (Zainuddin et al., 2020). In the e-DIPLOMA platform, this is integrated through real-time feedback and adaptive learning systems, where students are rewarded for completing assigned tasks.

However, it is important to recognize that not all students respond to gamification in the same way. While some may thrive in competitive environments, others may feel demotivated if they are not performing well on leaderboards (Majuri et al., 2018). Therefore, balancing gamification elements to cater to different student preferences is essential for maximising the benefits of these techniques in education.

In the e-DIPLOMA project we propose the implementation of gamification techniques to contribute to a more attractive, interactive and motivating learning experience. In this way, students are helped to develop critical skills while maintaining high levels of participation and enthusiasm throughout the course. With this objective, a state-of-the-art study of the main gamification techniques for online teaching was developed, a study of the existing tools for Moodle was carried out, and plugins, API services and complementary scripts were implemented to achieve an effective integration of different technologies.

5. Gamification Techniques Used in Education

5.1 State-of-the-art Gamification in Education

The scientific literature on gamification in educational settings has evolved significantly in recent years, with an increasing focus on how to effectively adapt and apply game elements to enhance learning. The following sections discuss the primary gamification approaches validated in the scientific literature within the educational field. First, the development of frameworks based on gamification taxonomies is examined, followed by a discussion on approaches for tailoring digital gamification in education.

5.1.1. Development of Gamification Taxonomies

Previous research in the field of gamification has produced several frameworks, yet most have been either general in scope or insufficiently tailored to educational contexts. The 6D Framework by (Werbach and Hunter, 2012) and the GAME Framework by (Marczewski, 2015) are two notable examples. The 6D Framework, based on the MDA framework (Hunicke et al., 2004), categorizes game elements into Dynamics, Mechanics, and Components. Similarly, the GAME Framework provides an extensive list of game elements but primarily categorizes them according to player profiles, offering limited guidance on their application in educational environments.

The need for a more targeted taxonomy specifically addressing the educational context led to the development of newer frameworks. (Klock et al., 2016) proposed a seven-step framework aimed at designing adaptive gamification in e-learning, utilizing 14 game elements derived from the 6D model. (Toda, A.M. et al., 2019) further advanced this work by proposing a taxonomy that divides game elements into Feedback and Property categories, although these frameworks have yet to be validated empirically. The first contribution of this study lies in the development of a detailed taxonomy, which enumerates distinct game elements and organizes them within a structured framework designed to aid educators and designers in implementing effective gamification strategies. The study was built on previous efforts by expanding and refining the taxonomy of gamification elements specifically for educational environments. The newly proposed taxonomy consists of 21 elements, organized into five dimensions: Performance, Ecological, Social, Personal, and Fictional. Each dimension addresses different aspects of the gamified learning experience, ensuring a comprehensive framework that can be systematically applied to analyze and design gamified educational environments. The dimensions are explained below:

Performance or Measurement dimension: This dimension focuses on elements that provide feedback to learners, such as points, levels, and badges. These elements are crucial for maintaining learner engagement by offering visible rewards and progress indicators. In this dimension we have Point, Progression, Level, Stats and Acknowledgement. Lack of this dimension means that the student may feel disoriented as their actions do not have any kind of feedback. For instance, points serve as a basic feedback mechanism, while levels and badges recognize achievement and progress.

Ecological dimension: This dimension encompasses elements related to the learning environment itself. These elements can be represented as properties. The elements in this dimension are Chance, Imposed Choice, Economy, Rarity, and Time Pressure. These elements contribute to the dynamics of the learning experience, introducing variability and decision-making processes that can enhance engagement and motivation.

Social dimension: Social elements like Competition, Cooperation, Reputation and Social Pressure are integral to fostering interaction among learners. These elements help create a collaborative or competitive environment, which can drive motivation and enhance the learning experience through social dynamics. The absence of Social elements can isolate students, as they will be unable to interact with their peers.

Personal dimension: Personal elements are directly tied to the learner's individual experience within the gamified environment. These include objectives, puzzles, and novelty, which help personalize the learning journey, making it more engaging and relevant to the learner's goals and interests.

Fictional dimension: This dimension, which is less commonly addressed in educational gamification, involves narrative and storytelling elements that provide context and meaning to the learning activities. By incorporating these elements, educators can create a more immersive and meaningful learning experience.

An important distinction made in this taxonomy is between intrinsic and extrinsic elements. Intrinsic elements are those that are subtly integrated into the learning environment, often going unnoticed by the learner, while extrinsic elements are overt and clearly perceived. This differentiation is crucial for understanding how various elements influence learner behavior and motivation. For example, points and badges are extrinsic elements that provide direct feedback, whereas the narrative might be an intrinsic element that subtly shapes the learner's experience. The proposed taxonomy is not only a tool for designing gamified learning environments but also for evaluating existing ones. By applying this taxonomy, educators and designers can systematically assess the presence and effectiveness of various gamification elements within a learning environment. This structured approach helps in identifying strengths and weaknesses in the design, allowing for informed adjustments that can enhance learner engagement and educational outcomes.

5.1.2. Approaches to tailor digital gamification in education

According to (Hong, Y. et al., 2024), the primary techniques identified in the literature can be categorized into three main approaches: personalization, adaptation, and recommendation, each relying on different types of user data and targeting unique aspects of the learning process:

Personalization: Personalization in gamification involves modifying the learning experience based on static user data, typically collected through surveys or questionnaires. This approach adjusts the gamified environment to meet the specific needs and preferences of the learners as determined by their responses to these surveys. For instance, static data might include user demographics or predefined learning styles, which remain relatively constant over time. The personalised approach often incorporates elements such as clear goals, challenges tailored to the user's skill level, and opportunities for customization. These elements are designed to align with the learner's motivational and psychological profiles, enhancing engagement and effectiveness. However, the review highlights a significant limitation in that static data collected through questionnaires may not always accurately reflect the dynamic nature of learners' needs, necessitating further development of more responsive personalization systems.

Adaptation: The adaptation technique goes a step further by continuously adjusting the gamified learning environment based on dynamic data gathered in real-time as learners interact with the system. This approach is seen as more accurate because it allows the system to respond to changes in the learner's behavior, performance, and preferences over time. Adaptive systems might modify tasks, provide real-time feedback, or alter challenges based on the learner's ongoing performance. For example, if a learner is struggling with a particular task, the system might reduce the difficulty or provide additional resources. This adaptability is crucial in maintaining learner engagement and ensuring that the gamification remains effective over time. The review emphasizes that while adaptation offers significant potential, it also requires sophisticated automated systems capable of processing and responding to real-time data without overwhelming educators.

Recommendation: The least utilized but potentially impactful technique is recommendation. This approach suggests learning activities or game elements based on the preferences of users with similar profiles. Unlike personalization, which relies solely on the individual's static data, recommendation systems aggregate data from a wider user base to predict and suggest content that might appeal to the learner. This method is widely used in commercial settings, such as e-commerce platforms, but has seen limited application in educational gamification due to the lack of sufficient empirical studies and the challenge of developing comprehensive user profile databases.

5.1.3. Gamified Virtual Reality Learning Environments

The integration of Virtual Reality (VR) in educational contexts has been significantly enhanced with the application of gamification techniques, aiming to improve learning outcomes and student engagement. This combination leverages the immersive nature of VR while incorporating elements such as points, levels, and real-time feedback, making it a powerful tool in education. For example, the GaMoVR project demonstrates how VR can be used to teach complex topics like UML modeling by combining a gamified environment with immersive VR experiences. This approach transforms learning from passive to interactive, requiring students to actively engage with the content to progress through mini-games that encapsulate key learning objectives (Yigitbas, E. et al., 2024).

Moreover, the integration of VR with gamification not only engages students but also allows for personalised and adaptive learning experiences. By offering tailored feedback and customizable learning paths, VR gamified environments address individual learning needs, making education more effective. In educational settings, such as those explored in the study by (Falah, J. et al., 2021), the inclusion of gamification in VR teaching applications has shown to increase motivation and knowledge retention, particularly when dealing with complex multidisciplinary subjects.

Through immersive VR environments, learners can experience simulations and tasks that mimic real-world scenarios, providing them with an opportunity to practice problem-solving in a gamified, risk-free setting (Kao & Ruan, 2022; Theodoropoulos & Lepouras, 2021). This approach not only enhances cognitive learning but also builds soft skills such as teamwork, particularly when collaborative modes are incorporated into the VR experience, as evidenced by studies in disciplines like medicinal chemistry (Maroukias, A., 2021) and software modeling (Yigitbas et al., 2024).

The scientific contribution of (Maroukias, A., 2021) provides a comprehensive framework for integrating gamification with fully immersive virtual reality (VR) learning environments. This framework emphasizes personalised learning through adaptive mechanisms, taking into account students' cognitive states and learning behavior. The authors highlight how gamified design and personalization can significantly improve learning experiences, making them more engaging and effective. The framework is based on the use of VR headsets, which immerse students in interactive 3D learning environments, offering a dynamic and adaptable learning process.

The authors (Lampropoulos, G., Kinshuk., 2024) raises several key issues with current solutions in the field of virtual reality (VR) and gamification in education and suggests areas for future work. The review identifies that while VR and gamification have shown promise in improving motivation, engagement, and learning outcomes, there is still limited understanding of how these elements interact when combined. The study highlights that more empirical research is needed to assess the long-term impact of gamified VR learning environments, particularly in terms of cognitive, social-emotional, and physical development.

5.1.4. Gamified Augmented Reality for Learning

Recent advancements in augmented reality (AR) have expanded the use of gamification techniques within educational environments, particularly in programming and computational thinking education. AR introduces interactive, real-world-like experiences where students can engage with virtual objects and receive real-time feedback, making abstract programming concepts more tangible. For example, in an AR-based system for programming education, students can use physical cards to assemble code components, which are then animated in real-time to reflect their programming logic. This interactive approach, as highlighted in studies like that of (Theodoropoulos & Lepouras, 2021), helps students better understand programming by making the learning process more engaging and interactive through the use of puzzles and challenges.

The application of gamified AR learning environments is particularly prevalent in STEM education. These systems often leverage game-based learning principles, such as competition, points, and rewards, to improve student engagement and motivation. For example, in a study by (Kao & Ruan, 2022), students who used a highly interactive AR-based system demonstrated improved programming achievements and higher motivation compared to those using less interactive or traditional learning methods. Additionally, AR systems often incorporate collaborative elements, where students can work together to solve problems, further enhancing their engagement and deepening their understanding of computational concepts.

5.1.5. Considerations for future studies

While the current review of the state of the art in gamification provides valuable insights, there are several areas that merit further exploration to optimize its application in educational settings. Most of the studies reviewed focus on the initial design and implementation phases of gamification systems. Future research should aim to analyze the long-term impact of these systems, providing insights into their sustained effectiveness and influence on student motivation and academic outcomes over time. Although the reviewed frameworks and techniques are applicable across various contexts, research should also focus on how to tailor gamification elements for students at different educational levels, from primary to higher education. This would enable the development of pedagogical strategies that are more closely aligned with the capabilities and needs of each group.

It is recommended that future studies incorporate adaptive gamification as an integral part of everyday educational practice, evaluating its effectiveness through longitudinal and experimental studies comparing adaptive and non-adaptive gamification. This would allow for examining the results more rigorously and better understanding the relative effects of each game element on students' academic performance and motivation.

Automated systems that adjust gamified activities in real time, based on students' needs and preferences, could free teachers from some of the administrative tasks, allowing them to focus more on creating quality educational content. However, it is important that teachers do not completely delegate to these systems, but continue to provide constant support and feedback to their students to maintain motivation and adherence in the learning process. Careful attention to students' actions and responses is essential to ensure that adaptive gamification is achieving its educational objectives and that students feel supported throughout the process.

For future implementations of gamification in education, it is essential to consider how the system's performance will be evaluated. Key indicators, such as student satisfaction, learning progress, and achievement of learning goals, should be examined to measure the effectiveness of the gamified system. However, these metrics can be controversial and difficult to assess, even in traditional learning environments. Therefore, it is recommended that future systems incorporate robust evaluation frameworks that track both qualitative and quantitative outcomes, providing a clearer understanding of how gamification impacts student engagement and educational achievement.

5.2 Gamification Techniques in the Popular Educational Applications Available on the Market

In the current landscape of educational technology, popular applications leverage various gamification techniques to enhance user engagement, motivation, and learning outcomes. These applications, ranging from language learning platforms to maths tutoring systems, incorporate a blend of intrinsic and extrinsic motivators to create a more immersive learning experience.

Points, Badges, and Leaderboards (PBLs). Many educational applications use the classic triad of points, badges, and leaderboards to motivate learners. For example, applications like Duolingo¹ use points to track progress, badges as rewards for completing specific milestones, and leaderboards to foster a sense of competition among users. This PBL system is effective in creating short-term motivation by providing clear, tangible goals and fostering a competitive learning environment (Saleem, A.N. et al., 2022; Oliveira, W. et al., 2023).

Adaptive Learning Paths. Applications such as Khan Academy² and Coursera³ implement adaptive learning techniques, where the content is tailored based on the learner's performance. These systems adjust the difficulty of tasks in real-time, ensuring that learners are neither bored by content that is too easy nor overwhelmed by content that is too difficult. This personalization of the learning journey helps in maintaining a learner's engagement over time by continuously presenting them with appropriate challenges (Oliveira, W. et al., 2023).

Gamified Quizzes and Interactive Content. Educational platforms like Kahoot!⁴ and Quizizz⁵ utilize gamified quizzes to make learning more interactive and engaging. These applications turn traditional quizzes into competitive games where students can earn points, see real-time feedback, and compare their scores with peers. This not only makes the learning process more enjoyable but also encourages active participation and reinforces knowledge through repetition (Lin, YL. et al., 2024).

Narrative and Storytelling. Some educational applications incorporate narrative elements to create a more engaging learning environment. For instance, Classcraft⁶ uses a role-playing game (RPG) approach where students can create characters, complete quests, and advance in a story. This narrative-driven approach immerses students in the learning process, making it more relatable and memorable (Oliveira, W. et al., 2023).

Incentive Structures: Platforms like Coursera⁷ and Edmodo⁸ often use certificates and other forms of recognition as incentives. These extrinsic rewards, such as certificates upon course completion, motivate students to complete courses and modules. While these rewards are not directly related to the learning content, they provide a clear goal that students strive to achieve, which can enhance completion rates and overall motivation (Lin, YL. et al., 2024).

Social Interaction and Collaboration: Many applications, such as Edmodo and ClassDojo⁹, integrate social features that allow students to interact, collaborate, and share their achievements. Social interaction elements, such as group challenges and peer feedback, enhance the learning experience by fostering a sense of community and encouraging collaborative learning (Oliveira, W. et al., 2023).

Progress Tracking and Feedback: Many applications include features that allow users to track their progress over time and receive immediate feedback, which is key to sustaining engagement. For example, Duolingo provides progress tracking through daily streaks and skill levels.

¹ es.duolingo.com

² khanacademy.org

³ coursera.org

⁴ kahoot.com

⁵ quizizz.com

⁶ hnhco.com/programs/classcraft

⁷ coursera.org

⁸ edmodo.online

⁹ classdojo.com



Customization and Avatars: Applications like Minecraft: Education Edition¹⁰ allow students to Customise avatars and learning experiences, which can enhance motivation by giving students a sense of ownership over their learning.

Challenges and Rewards: Platforms such as Prodigy¹¹ and BrainPOP¹² utilize challenges that students must complete to earn rewards, which are then used to unlock new levels or features within the app.

Virtual Economy: Some applications incorporate virtual economies where students can earn virtual currency for completing tasks, which they can then spend within the application to customise their experience or unlock new content. This technique is often seen in apps like Classcraft.

5.2.1 Research across different educational levels, subjects, and student demographics

Recent studies continue to emphasize the effectiveness of gamification techniques in educational contexts, highlighting their ability to enhance student engagement and learning outcomes. However, the impact of these techniques can vary significantly depending on the educational level, subject matter, and the demographic characteristics of the learners involved. The literature suggests that gamification techniques such as points, badges, and leaderboards (PBL) are particularly effective in primary and secondary education, where they foster a competitive spirit and provide immediate feedback that can be highly motivating for younger students. For example, platforms like ClassDojo and Kahoot! have been widely adopted in K-12 education for this reason. However, in higher education, while these techniques are still used, their effectiveness can depend more heavily on the design of the learning activities and the specific context in which they are applied. There is a need for further research to explore how these techniques can be optimized based on their education level, taking in account different motivational drivers (Huang, R. et al., 2020; Smiderle, R. et al., 2020).

Another area that requires more investigation is how gamification techniques interact with different student demographics and learning styles. For instance, studies have shown that the effectiveness of gamification can be influenced by students' personality traits, such as openness and conscientiousness, as well as by their prior gaming experience. These factors can affect how students engage with gamified elements, with some students finding these techniques more motivating than others. This underscores the importance of tailoring gamification strategies to meet the diverse needs of students, which is a growing area of focus in recent research (Smiderle, R. et al., 2020).

5.2.2 Challenges and Future Directions

Despite the positive impacts, there are also challenges associated with the implementation of gamification in education. One of the key issues is the potential for over-reliance on extrinsic motivators, such as points and badges, which can sometimes undermine intrinsic motivation if not balanced properly. Additionally, there is still much to learn about how to design gamified environments that are inclusive and effective for all students, regardless of their background or learning preferences.

Future research should focus on longitudinal studies that examine the long-term effects of gamification on learning outcomes and how these effects vary across different educational settings. Moreover, there is a need for more studies that explore the use of advanced gamification techniques, such as adaptive learning paths and personalised feedback, which can provide a more tailored and effective learning experience (Smiderle, R. et al., 2020 ;Huang, R. et al., 2020).

¹⁰ education.minecraft.net

¹¹ www.prodigygame.com

¹² brainpop.com



6. Gamification Techniques Introduced into e-DIPLOMA Platform

6.1 Gamification Methods proposed

In the e-DIPLOMA project, we have developed and integrated two gamified learning environments based on the use of Virtual Reality (VR) and Augmented Reality (AR) technologies. These gamified environments are designed not only to engage students but also to facilitate complex learning objectives such as programming, electronics, and system assembly in an interactive, immersive environment.

These gamified solutions, when analysed separately, constitute an effective learning tool. On the one hand, they are aligned with the learning objects of the course, contributing to the assimilation and practice of the teaching content, while making the learning process motivating and fun. If we analyse them as part of a whole, that is, as part of the Moodle course, they constitute a fundamental element or tool of gamification within the course. They complement the course, since they provide motivating aspects, challenges, engagement and collaboration, while following the learning objectives of the course, with each module of the course providing feedback to each other to accumulate points and keep track of the learning progress. This section outlines how the aspects of these gamification techniques enhance the learning process.

6.1.1 Gamified VR learning environment

The first gamification method revolves around a block programming mini-game implemented in Virtual Reality. This game is designed with two versions:

1. Single-player: where the student learns to program a robot car in isolation.
2. Multiplayer collaborative: where two students cooperate to achieve the task.

Gameplay and Learning Objectives

The game takes place in a virtual environment that resembles a grid-like terrain with various obstacles. The student's goal is to program the movement of a robot car, assembled during a prior AR-based activity, to navigate the terrain and collect the humidity data from plants using sensors. The game consists of various levels that increase in complexity as the user progresses. The initial levels introduce basic programming concepts, allowing the user to apply these concepts in practice and reinforce their knowledge. As the user advances, the game incorporates more complex programming elements, such as offering new solutions to problems using loops (for loops) or actions under conditional statements (if conditions).

The learning objectives are focused on teaching students block programming concepts, such as:

- Move-forward commands to direct the robot through the terrain,
- For loops (used to move the car over multiple steps),
- Conditional logic (if statements) to manage obstacles or changes in direction.

Each programming decision impacts the robot's ability to navigate obstacles, thus providing immediate feedback and reinforcing programming logic through practical application. Additionally, the game introduces a real-world context by using sensors to measure the plants humidity. This immersive

environment connects the digital world with realistic situations, further enhancing the student's understanding of programming concepts applied to Internet of Things (IoT) systems.

6.1.2 AR-based Gamified Application to Learn Electronics

The second proposal introduces an AR-based learning module aimed at teaching students about electronics and circuit assembly. In this module, students are tasked with assembling a robot car using Arduino circuits and sensors. This is the same car that is later used in the VR block programming game.

Learning through Augmented Reality

AR provides students with the ability to visualize and interact with 3D components of the car's electrical system. They can manipulate parts, observe connections, and follow real-time instructions on how to assemble the circuits correctly. This interactive process improves retention and understanding, as it allows students to see the physical and functional aspects of the car's design while learning the principles of electronics.

The AR module introduces gamification elements such as Progress tracking: where each successfully assembled part of the car provides immediate feedback through the scores obtained in the questionnaires to demonstrate what has been learned. The game also offers a virtual tutor mode where the user can review the concepts they learned in a previous virtual class within the Moodle course.

6.1.3 Integration of VR and AR environments

What distinguishes these environments as gamification solutions is their integration in a single platform such as Moodle. Students first engage with AR to build the robot car using Arduino circuits and sensors. Then, they transition to the VR environment to program and control the same car in a simulated environment. This cross-technology continuity not only reinforces the learning objectives but also adds depth to the student's experience by linking hands-on physical assembly with the virtual application of programming skills.

By combining AR's tangible learning process with VR's immersive programming tasks, students are able to see the real-world impact of their programming skills on the assembled device. This synergy between VR and AR is an integrative gamification approach in the context of e-learning, as it connects multiple learning dimensions (Personal, Sensory, Ecological) while maintaining a cohesive narrative across platforms.

6.1.4 Collaborative Learning and Personalization

The multiplayer version of the VR-based learning environment emphasizes collaborative learning by requiring two students to work together to achieve the task. This cooperation adds a social dimension to the gamification process, fostering teamwork and communication skills while still focusing on individual learning outcomes.

Additionally, the personalised learning paths in both mini-games adapt to each student's progress. The difficulty of programming challenges in the VR game increases based on the student's previous performance, offering personalised feedback and keeping learners engaged by tailoring the difficulty to their skill level.

6.2 A comprehensive framework for implementing gamification in e-Diploma

The primary contribution of this work is the proposal of a comprehensive reference framework, tailored to the objectives of the e-Diploma project, enabling the streamlined deployment of gamified courses that incorporate disruptive technologies such as VR and AR, alongside state-of-the-art gamification techniques validated across diverse educational environments. The framework is represented in Table 1. The represented framework outlines the gamification dimensions in education that have been selected and adapted for our use case in the Moodle course 'Learn Block Programming and Electronics.' However, it is possible to add, remove, or modify any of the perspectives mentioned.

The framework is designed to represent the three essential phases and strategies needed to facilitate the development and deployment of a gamified course using the techniques we have integrated. These phases encompass data preparation, the implementation of gamification methods, and potential educational applications. This new methodological perspective is a significant contribution of this project to the state of the art. In addition, it includes the deployment of mini-games that incorporate disruptive technologies such as virtual reality (VR) and augmented reality (AR), which, to our knowledge, have not yet been strategically integrated into Moodle courses in the scientific literature.

The selection of gamification techniques implemented in the Moodle-based e-Diploma platform was motivated by the need to create a structured, engaging and motivating learning environment. This environment complements the innovative learning methodologies we propose, which make use of VR and augmented reality AR. Below is a detailed explanation of the chosen techniques and the rationale behind their incorporation. The gamification elements used in the e-Diploma platform are grouped and detailed by dimension.

The framework proposed for gamification in e-Diploma is intended to be implemented using the Learning Management System Moodle. The framework is structured around several interconnected dimensions, each contributing uniquely to the learning experience while working in tandem to create a cohesive and engaging environment for students.

The Performance/Measurement Dimension serves as the foundation by focusing on the tracking and evaluation of student progress. Data such as points, levels, and feedback from quizzes and assignments can be recorded using several Moodle plugins such as the *Level Up XP plugin*. This data is crucial because it provides a tangible way to measure learning outcomes and reward students for their achievements, thus fostering a sense of accomplishment. By consistently monitoring these metrics, the platform ensures that students stay engaged and motivated through feedback and the recognition of their progress.

Next, the Ecological Dimension complements the performance metrics by introducing randomness and choice into the learning environment. This dimension uses methods like time-bound quizzes and random rewards to introduce variety and maintain engagement. For example, a time-limited quiz might not only test knowledge but also offer unexpected bonuses upon completion, adding an element of surprise. This randomness interacts with the performance data by keeping learners on their toes and motivated to continue engaging with the content, as they don't always know what will happen next.

The Social Dimension enhances the gamification experience by leveraging peer interaction. Leaderboards and collaborative activities, such as the VR multiplayer game, promote both competition and cooperation. These social elements rely on the data generated by student performance and interactions. For instance, while individual progress is tracked, leaderboards display the relative achievements of peers, encouraging students to push themselves. The social dynamics fostered through

these tools ensure that learners are not only competing but also collaborating, as seen in group tasks that require teamwork to achieve collective goals.

Personalization, addressed in the Personal Dimension, tailors the learning experience to each student. Data such as quiz results and task completions are tracked, and content is unlocked based on individual progress and competency. This dimension highlights the role of personalised learning pathways, where the system adapts to the learner’s needs by unlocking new materials or providing tailored feedback as they advance through the course. personalised paths are built upon the data collected in the performance and ecological dimensions, ensuring that each student progresses at their own pace, while the social elements offer a communal sense of achievement.

Finally, the Fictional Dimension can integrate immersive storytelling within the virtual and augmented reality components of the platform. Here, the data from students’ progress in the VR and AR environments contributes to a cohesive narrative, whether it’s assembling an electronic car with sensors in AR or programming the car instructions through block programming in VR. These fictional elements not only make learning more engaging but also tie into the personal and ecological dimensions by providing context and meaning to the students’ actions. The narrative strengthens the sense of purpose in the learning process, giving students a reason to apply the programming or electronics knowledge they’ve gained in previous modules.

Table 1. A Framework for Gamification in the e-Diploma Platform: Dimensions, Data Types, Methods, and Application.

	Performance	Ecological	Social	Personal	Fictional
DATA	Points earned, levels achieved, completion times	Interaction data, randomization triggers, user decision paths	User interaction logs, social networks, feedback systems	Learner goals, quiz results, task completion	Narrative elements, progress within storylines
METHOD	Points, badges, stats tracking, feedback loops	Randomised events, imposed choice, dynamic time pressures	Leaderboards, cooperative challenges, reputation systems	Unlocking new content based on progress, dynamic adaptation	Storytelling techniques, scenario-based challenges
APPLICATION	Performance analysis, skill tracking, adaptive feedback	Dynamic content flow, decision-based paths, event variation	Collaborative learning, competitive challenges, peer review	Competency-based learning paths, quizzes, goal setting	Immersive story-driven activities, VR/AR integration



6.3 Demonstration on how to adapt the gamification framework to the e-Diploma platform.

Below, we detail how the gamification framework was implemented within the e-Diploma platform, specifically in the Moodle course titled 'Learn Block Programming and Electronics.' Each gamification strategy employed was designed according to the dimensions outlined in the proposed framework. The following sections provide an overview of these dimensions and explain the specific solutions implemented within the platform.

6.3.1 Performance/Masurement Dimension

Points for Completed Activities. Awarding points for completing tasks or activities directly ties student actions to rewards, reinforcing positive behaviors and encouraging consistent engagement with the course material. This approach ensures that students are continuously motivated to participate in activities, complete assignments, and interact with the learning content. The use of the "Level Up! XP-Gamification"¹³ Moodle plugin to manage point distribution allows for flexibility in how points are awarded, enabling instructors to tailor the system to the specific needs of the course and the learners. Figure 1 shows the panel with the instructions in order to earn points and level up, and also shows the defined levels and points needed to reach them.



Figure 1. Panel with the instructions, defined levels and points needed to reach them.

¹³ https://moodle.org/plugins/block_xp

Experience Levels. Assigning experience levels to students based on their progress provides a clear and motivating pathway through the course content. The XP plugin allows for the customization of levels, ensuring that the learning curve is appropriately challenging and rewarding. As students accumulate points and advance to higher levels, they gain a tangible sense of achievement, which is crucial in maintaining motivation. Every time a user levels up, a congratulatory notification will be displayed inside a pop-up window. Figure 2 shows the block with the level reached by the authenticated user. The badges associated with the levels also can be modified.

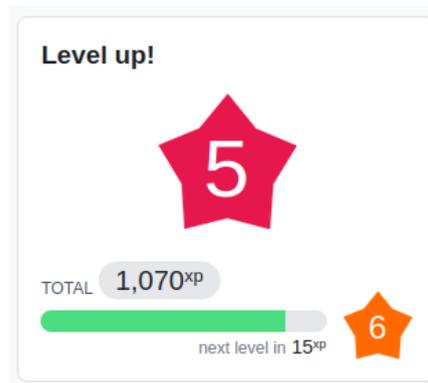


Figure 2. Block that shows the level reached by the authenticated user.

Achievement Medals or Badges. The use of achievement medals or badges serves to recognize and celebrate student accomplishments, providing visible markers of success that can be shared and displayed. By utilizing Moodle's built-in "Badges" plugin, we ensure that students receive immediate recognition for their achievements, which can be particularly motivating in a e-learning environment. Badges are awarded for mastering specific competencies or reaching certain milestones, offering students a clear indication of their progress and the skills they have acquired. Additionally, the ability to carry these badges in a digital 'backpack' allows students to consolidate and showcase their achievements outside of the Moodle platform, such as on social media or professional profiles. This feature not only reinforces intrinsic motivation by providing tangible and visible recognition, but also fosters self-esteem and pride in a job well done. By being able to share their achievements, students can build a digital portfolio that reflects their development of skills throughout the course, which can be valuable for future educational or professional opportunities.

In the project we have decided to use the default plugin that is implemented in Moodle "Badges". The purpose is to assign a badge per competency or level achieved by the user in the course. To do this, it is necessary to first define the necessary competencies to achieve during each stage of the course. Moodle offers the possibility of carrying your badges in your "backpack", which enables you to link the badges earned to external services where you can share the official badges earned even in other courses. Every time a badge is earned it is also shown through the notification panel. Figure 3 shows the Panel for "Excellent work" Badge configuration. In this panel among other settings can be loaded the badge image and it must set the criteria for awarding this badge. Figure 4 shows the student profile panel, it displays the badges earned by the student. Badge achievements are also notified in the authenticated user's notification panel, see figure 5.

[Preferences](#) / [Manage badges](#) / [Excellent work!](#)

Excellent work!



Download

Excellent work!

Awarded to Miguel Gómez

Issued 23 May 2024, 2:00 PM

Issued by Virtual Classroom e-Diploma Project

You have done an excellent job!

Criteria

Acquired competence related to block programming using virtual reality

- The following competencies have to be completed:

Block programming 1

VR programming competences - Competency

Path: [VR programming competences](#) /

[More details](#)

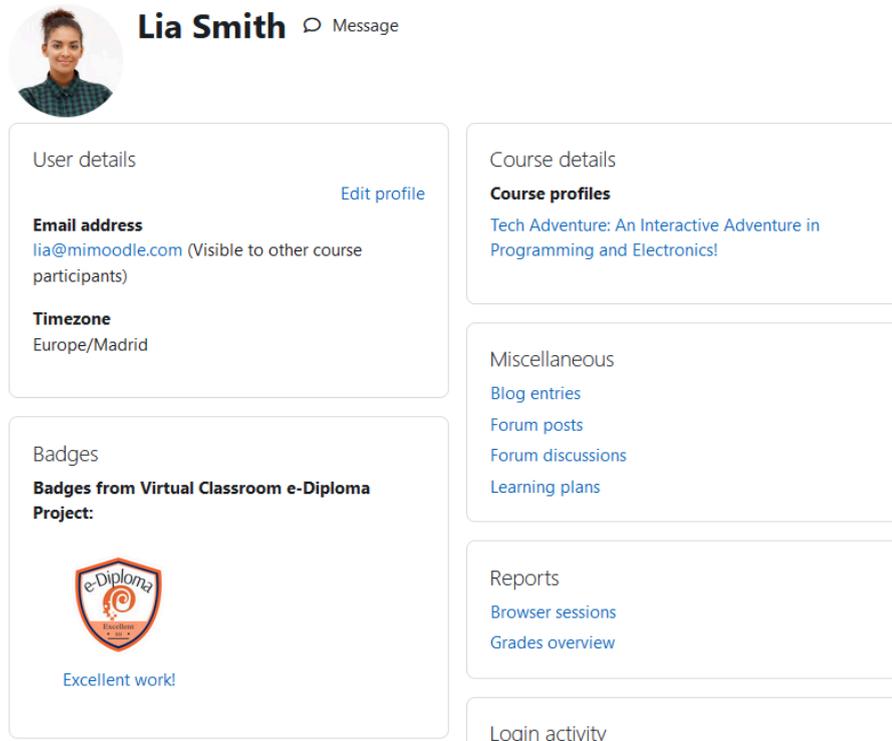
Language

English

Image author's name

Indira Lanza

Figure 3. Panel for “Excellent work” Badge configuration.



 **Lia Smith** [Message](#)

User details [Edit profile](#)

Email address
lia@mimoodle.com (Visible to other course participants)

Timezone
Europe/Madrid

Course details

Course profiles
[Tech Adventure: An Interactive Adventure in Programming and Electronics!](#)

Miscellaneous

[Blog entries](#)
[Forum posts](#)
[Forum discussions](#)
[Learning plans](#)

Reports

[Browser sessions](#)
[Grades overview](#)

Login activity

Badges

Badges from Virtual Classroom e-Diploma Project:



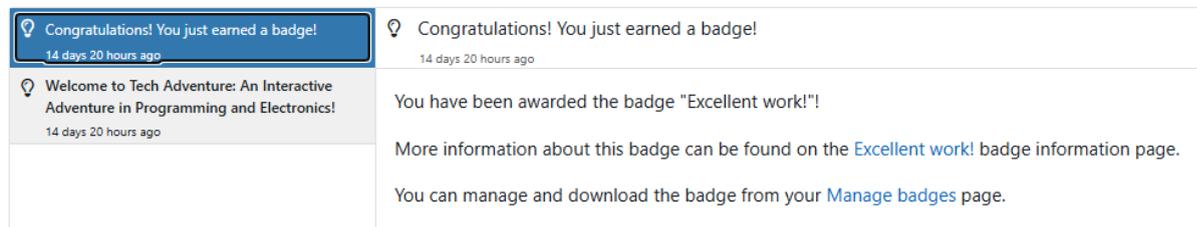
Excellent work!

Figure 4. Panel detailing the profile of the authenticated user. It displays the badges earned by the student.



**Miguel Gómez** Message

Notifications



The screenshot shows a notification panel for Miguel Gómez. It contains two notifications:

- Notification 1:** "Congratulations! You just earned a badge!" (14 days 20 hours ago). This notification is highlighted with a blue border. To its right, the text reads: "Congratulations! You just earned a badge!" (14 days 20 hours ago).
- Notification 2:** "Welcome to Tech Adventure: An Interactive Adventure in Programming and Electronics!" (14 days 20 hours ago). To its right, the text reads: "You have been awarded the badge 'Excellent work!'". Below this, it says: "More information about this badge can be found on the [Excellent work!](#) badge information page." and "You can manage and download the badge from your [Manage badges](#) page."

Figure 5. The badge achievement is displayed in the authenticated user's notification panel.

Integration with external backpacks. In Moodle, we have configured the "Manage backpacks" option to integrate the badges earned by students with the well-known tool Badgr.io. By enabling this feature, students can automatically connect their Moodle-earned badges to their Badgr backpack, allowing them to display, store, and share their achievements beyond the Moodle platform. Badgr.io (<https://badgr.com/backpack/badges>) offers a robust system for managing digital credentials, enabling students to carry their badges across different platforms and showcase their learning accomplishments on social media, professional profiles, or job applications. This integration enhances the value of badges by making them portable and verifiable across various educational and professional environments. The ability to manage and share badges externally through Badgr also incentivizes learners by giving them a tangible, portable record of their achievements that can be used for lifelong learning and career progression.

Content unlocking and feedback through competencies acquisition. In the LMS Moodle it is possible to define a competency framework with a set of competencies associated with the effective completion of the learning modules of a course. The acquisition of a new competency within a Moodle course can be associated with the gamification technique of 'Competency unlocking'. This technique involves granting students access to new skills, knowledge, or additional course content as they achieve certain goals or competency levels. In Moodle, this can be configured using competency frameworks that allow students to unlock new competencies or modules after completing specific tasks or demonstrating certain skills. This technique not only motivates students to progress and complete the necessary tasks but also provides a clear sense of progression and achievement in their learning process.

Competency unlocking is also closely related to level and point systems, where students 'level up' or progress in the course by demonstrating that they have acquired the necessary competencies, which is aligned with the principles of competency-based learning (Khaldi et al., 2023). Additionally, the acquisition of a new competency in a Moodle course can be associated with the gamification technique of "Feedback". In the context of gamification, feedback not only refers to comments on performance but also to any form of response or recognition that a student receives in response to their actions, including the granting of new competencies.

In Moodle, we have defined a competency framework with a set of competencies associated with the effective completion of each of the modules defined in the course. For example, there will be a competency associated with virtual learning of block programming, another competency will be associated with the programming of electronic circuits, among others. Next figure 6 shows the



competence “Block programming” achieved by a student in the course after finalizing the activities related with playing the game.

Course competencies

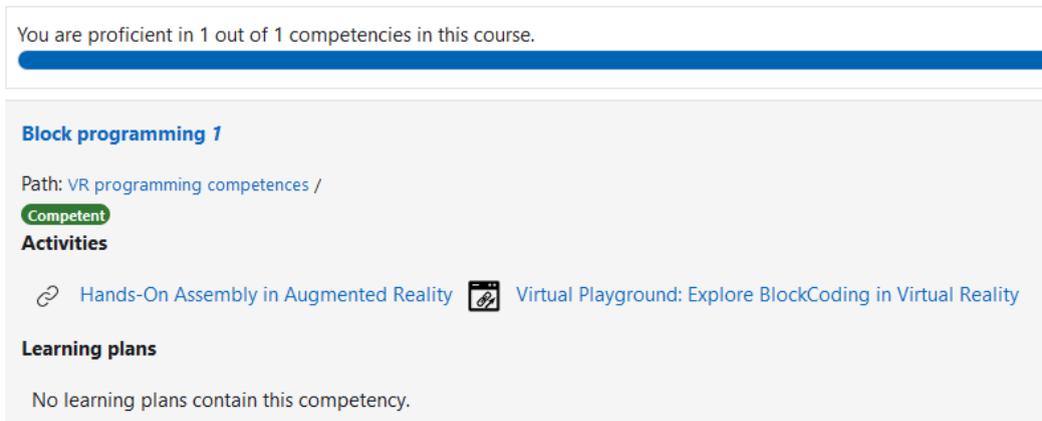


Figure 6. Course competencies achieved.

6.3.2 Social Dimension

Leaderboards. The integration of leaderboards through the "Level Up XP! -Gamification" Moodle block plugin is designed to foster a sense of healthy competition among students. The objective of this tool is to motivate students to engage with the course, as the more they interact with various resources, the more points they accumulate and the higher their level becomes. By showing how students perform relative to their peers, the leaderboard encourages learners to improve their performance continuously. The competitive element is particularly effective in maintaining engagement and motivation, as students can see their progress and strive to reach higher positions. The leaderboards are dynamically updated, offering real-time feedback that helps sustain student interest and participation throughout the course.

Level Up! XP-Gamification is a block type plugin developed for the Learning Management System Moodle and it is part of sets Experience Points (XP). The XP plugin offers a comprehensive set of built-in features to enhance learning outcomes. Learners are motivated through experience points and individual leaderboards, with points automatically attributed for their actions. A progress block keeps learners updated on their current level and their journey towards the next one, while a leaderboard showcases their ranking among peers. Notifications celebrate learners' achievements as they level up, fostering a sense of accomplishment. Instructors benefit from a detailed report on their learners' levels, with the ability to Customise levels, points requirements, and appearance. The plugin ensures total control over points allocation per action. Also instructors can use various code snippets to enhance their content material with gamification elements, or to display or hide content based on a learner's level. Additionally, content can be unlocked upon reaching specific levels. XP is fully compliant with the General Data Protection Regulation (GDPR), which is a European Union regulation designed to protect the privacy and personal data of users. This means that the plugin handles student information and data in a way that meets the strict privacy requirements set by this regulation. In this way, it provides a privacy-friendly gamification solution for Moodle users. Next figures 3 and 4 show some screenshots of the plugin.

Level up!

Rank	Level	Participant	Total	Progress
1	9	Ellie de Morgan	3,514 ^{XP}	next level in 328 ^{XP}
2	9	Jon Ford	2,973 ^{XP}	next level in 869 ^{XP}
3	8	Benjamin Franklin	2,824 ^{XP}	next level in 39 ^{XP}
4	7	Gavin Jackson	1,660 ^{XP}	next level in 450 ^{XP}
5	6	Séléna Garnier	1,331 ^{XP}	next level in 200 ^{XP}
6	6	Delfino Fernandes	1,176 ^{XP}	next level in 355 ^{XP}
7	6	Zoe Dixon	1,088 ^{XP}	next level in 443 ^{XP}
8	5	Wyatt Snyder	917 ^{XP}	next level in 168 ^{XP}
9	3	Alice Chambers	373 ^{XP}	next level in 106 ^{XP}
10	1	Laura Jørgensen	85 ^{XP}	next level in 35 ^{XP}

Figure 7. Level Up XP - Gamification Leaderboard panel.

Level up!

Participate in the course to gain experience points and level up!

TOTAL 147^{XP}

next level in 129^{XP}

RANKING

2

+138

3

4

-27

RECENT REWARDS

9 ^{XP}	Course viewed	4m
9 ^{XP}	Course module viewed	1d
9 ^{XP}	Course viewed	1d

Info
Leaderboard

Figure 8. Level UP XP-Gamification block. The block displays the authenticated user's position in the ranking, along with the two users immediately ahead and behind them in the ranking.



Cooperation to reinforce skills. Cooperation is another social perspective that we also incorporate into the platform through the block programming module using Virtual Reality. This activity was designed based on two options: with a single player and with two players. In the two-player mode, students collaborate to solve programming challenges, sharing tasks and working together to achieve the best results. This cooperative approach encourages peer-to-peer interaction, allowing students to communicate, exchange ideas, and learn from each other in real-time, reinforcing both their programming skills and teamwork abilities. By integrating cooperation into the VR experience, the platform fosters a sense of collaboration, which enhances engagement and provides a more dynamic learning experience.

6.3.3 Ecological Dimension

Learning Objects Recommender. In the e-DIPLOMA platform, we have implemented two block plugins for Moodle designed for learning object recommendation. The recommendation systems implement gamification techniques that are in high demand in the field of e-Learning: personalization, adaption and recommendation (see section 5.1). These systems are designed to personalize the learning experience of students by suggesting content that is most relevant to their progress and needs. This personalised approach increases students' motivation, engagement, and overall learning outcomes by adapting the learning process through intelligent recommendations. Figure 9 shows the e-Recommender block. The block will be displayed throughout the student's experience within the course, listing recommended learning objects based on the student's latest actions. For detailed information on the implementation of these systems, refer to "Deliverable 3.4".

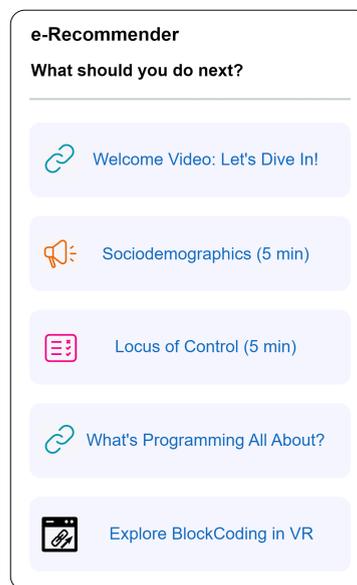


Figure 9. e-Recommender block.

The first recommendation system is a hybrid model that integrates collaborative filtering and Knowledge-Based Filtering techniques. This system is particularly useful for adapting content based on students' interactions and progress within the course. By analyzing the chronological sequence of user behavior, this system ensures that the recommended learning objects follow a logical and pedagogical order, enhancing the educational flow. For example, if a student successfully completes a set of tasks related to block programming, the system might recommend more advanced programming modules or even related concepts in electronics. This system dynamically tracks the student's actions and adjusts

its recommendations to keep them engaged with new, progressively challenging material. The gamification element here lies in the system's ability to motivate students through a sense of accomplishment as they unlock new content that matches their skill level, further reinforcing their progression and engagement within the course.

The second system focuses on user-based collaborative filtering and the use of knowledge graphs to construct personalised and ordered learning paths. This system personalizes the learning experience by recommending paths that have been successful for students with similar learning patterns or levels of achievement. For instance, if a student demonstrates similar learning behavior to a peer who excelled in programming, the system will recommend the learning objects that were instrumental in that peer's success. Additionally, the system uses graph theory to ensure that the recommended learning path follows a logical progression, taking into account both the student's current level and the instructor's predefined course structure. The gamification element in this system comes from the integration of progress tracking and personalised rewards, where students can unlock badges or levels as they follow their recommended path and achieve competencies.

Data is collected dynamically at various stages of the student's interaction with the platform. For instance, every time a student completes a task, quiz, or module, the system logs this data—tracking the student's performance, completion time, and even comparing these metrics with other users. This allows the recommendation system to update and provide real-time suggestions. The recommendation process is primarily influenced by a combination of collaborative filtering (comparing behavior patterns with peers) and knowledge-based filtering (aligning content with the course structure and the student success levels).

Both recommendation systems incorporate key gamification elements—such as progression, unlocking new content, and personalised feedback—that are essential in maintaining high levels of student motivation and engagement. By continuously adapting to the student's evolving knowledge and performance, these systems ensure that learners remain challenged and interested in their studies, which is a critical factor in the e-DIPLOMA platform's success.

6.3.4 Personal dimension

Enhancing Sensation through virtual and augmented reality (VR/AR). In the Moodle-based *e-Diploma* platform, Virtual Reality and Augmented Reality activities align with the "Personal dimension" of gamification. For example, after students complete theoretical video modules within Moodle, they engage in interactive VR or AR activities that immerse them in learning how to program or work with Arduino. These activities offer a more stimulating and interactive experience, leveraging the *Sensation* aspect by making learning more engaging and enhancing the educational process through immersive technologies. The following images illustrate the scenarios for the block programming learning activity using VR. Figure 10 depicts the single-player scenario, while Figure 11 showcases the collaborative version of the game, where two players work together to achieve the best results and simultaneously reinforce their programming knowledge. Finally, Figure 12 shows a student interacting with the augmented reality application to learn how to configure sensor electronics.

Improving the Sensation dimension in gamification through the use of Virtual Reality (VR) and Augmented Reality (AR) enhances the immersive and interactive elements of learning environments by engaging students' senses in ways that traditional methods cannot. VR allows for multi-sensory stimulation that provides a more engaging, stimulating, and impactful learning experience. Through immersive environments, students explore realistic or fantastical worlds tied to the course content, increasing engagement and motivation. Interaction and feedback are enhanced as students manipulate virtual objects and solve problems in dynamic scenarios, reinforcing their understanding of the material. The multi-sensory experience makes abstract concepts more tangible and easier to grasp, promoting

active learning through direct application of knowledge. This sensory-driven approach, combined with hands-on scenarios, offers students a deeper and more stimulating educational experience, helping them retain knowledge and remain motivated throughout their learning journey.



Figure 10. A single-user virtual reality game scenario designed to teach block programming.



Figure 11. A collaborative multi-user virtual reality game scenario designed to teach block programming



Figure 12. The user interacts with an augmented reality application to learn how to configure sensor electronics.

6.3.5 Fictional dimension

Narrative in the Moodle Context. In the course, Narrative can be introduced through progress-based stories that students follow as they advance. For example, the storyline of saving the Amazon or stopping a zombie invasion, which is already present in the VR game, can extend to Moodle by setting up missions or side-quests that students engage with through quizzes, assignments, and discussion forums. Each student's decisions and quiz scores could affect the outcome of the story, tying the learning progress with the evolving narrative.

Example: After completing a quiz in Moodle, students receive a story update that ties their performance to the progress in saving the Amazon. Their decisions during quizzes or assignments (such as using specific programming solutions or sustainable options) influence the direction of the narrative, giving them a sense of agency over the storyline.

Storytelling in the Moodle Context. In Moodle, Storytelling can be implemented through text prompts, video content, and audio cues that provide context to each module. The course content, such as introductory videos or post-quiz explanations, can contain references to the larger narrative, reinforcing the storyline as students progress through theoretical modules before engaging in VR/AR activities. This continuous immersion through storytelling creates a cohesive learning experience that connects theoretical knowledge with practical application in the virtual worlds.

Example: Before beginning the VR activity, Moodle could provide students with a narrative-driven video that outlines their next mission in the game, such as defending a virtual village or protecting the Amazon. Upon completing the task, they are prompted with a post-assignment reflection in Moodle, reinforcing how their coding or engineering solutions helped advance the story.

Finally, Table 2 provides a concise overview of the dimensions discussed in the previous sections, serving as a quick reference tool for better understanding and clarity.

Table 2. This table categorizes the key gamification elements based on their corresponding dimension implemented in the e-Diploma platform.

Dimension	Competition elements in e-Diploma platform
1. Performance/ Measurement	<p>Points for Completed Activities: Awarding points for completing tasks, managed by the "Level Up XP" plugin, reinforces engagement by tying rewards to specific actions.</p> <p>Experience Levels: Levels provide a clear path for progression based on points accumulated, encouraging motivation.</p> <p>Achievement Medals or Badges: Badges are awarded for mastering specific competencies, fostering recognition of accomplishments.</p> <p>Content Unlocking and Feedback through Competencies Acquisition: Content is unlocked as students acquire new competencies, providing real-time feedback and a sense of progression.</p>
2. Ecological	<p>Imposed choice by learning objects Recommender: A recommendation system offers learners multiple content options or paths, requiring them to make decisions, actively engaging them in their journey.</p>
3. Social	<p>Competition element - Leaderboards: The leaderboard feature motivates students by fostering competition, showing their progress relative to peers.</p> <p>Cooperation to reinforce skills: Encourages peer-to-peer interaction, allowing students to exchange ideas in real-time, reinforcing both their skills and teamwork abilities.</p>
4. Personal	<p>Sensation - VR and AR activities: Virtual Reality(VR) and Augmented Reality(AR) activities immerse learners in programming and electronics through interactive experiences, enhancing engagement by stimulating the senses. These activities align with the "Sensation" element of the Personal dimension of gamification.</p> <p>Novelty: Unlocked hidden activities keep the environment dynamic and engaging, preventing stagnation.</p> <p>Objectives: Clear goals, such as achieving certain scores in quizzes or the VR game, motivate learners to complete tasks.</p> <p>Puzzle: Cognitive challenges through quizzes, challenges, and programming in VR provide mental stimulation and problem-solving opportunities.</p>
5. Fictional	<p>Narrative: For example, one of the proposed solution in the VR-based programming game, students embark on a quest to save the Amazon or protect the world from a zombie invasion. This narrative gives context and meaning to the tasks, increasing engagement and immersion.</p> <p>In Moodle, students follow a storyline through quizzes, assignments, and progress-based stories that extend from the VR games. The decisions made during these activities influence the evolution of the narrative, giving students control over the story's direction.</p> <p>Storytelling: The game's environments are supported by audio cues and story-driven prompts, guiding students through different "worlds" in a structured manner, enhancing the overall experience through immersive storytelling.</p>

	<p>Story-driven prompts, audio cues, and videos embedded in Moodle provide context and continuity, connecting theoretical learning with the VR-based practical applications. These narrative elements immerse students further into the learning experience, creating a cohesive flow between theory and practice.</p>
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6.4 Technical Aspects to Incorporate Gamification Techniques into the e-DIPLOMA Platform

The successful integration of gamification techniques into the e-DIPLOMA platform requires careful consideration of various technical aspects. This section outlines the necessary steps for configuring and implementing key gamification elements, such as points systems, experience levels, leaderboards, and achievement badges, within the Moodle-based environment. By leveraging specific plugins and customising them to fit the course structure, instructors can create an engaging and motivating learning experience.

The technical aspects to be taken into account in order to deploy the selected gamification techniques in the context of the e-Diploma project within Moodle are described below. Details are provided on the installation and configuration of the selected Moodle plugins and tools, as well as on new web services that we have developed. Reference examples are also proposed for the implementation of the gamification elements. It discusses how these gamification techniques were integrated with the virtual reality platform.

6.4.1 Plugin Integration and Configuration in Moodle

A. Moodle Plugin Installation: Step-by-Step Guide:

Step 1: Download the Plugin

1. Navigate to the Moodle plugins directory at Moodle Plugins (<https://moodle.org/plugins/?q=>).
2. Search for "Level Up XP - Gamification" and "Badges".
3. Download the latest version of each plugin to your computer.

Step 2: Upload and Install the Plugin

1. Log in to your Moodle site as an administrator.
2. Go to Site administration > Plugins > Install plugins.
3. Click the "Choose a file" button under the "Install plugin from ZIP file" section.
4. Select the downloaded ZIP file from your computer and click "Upload this file".
5. After uploading, click "Install plugin from the ZIP file" to proceed.
6. Moodle will perform a plugin validation check. If the plugin passes, click "Continue".
7. Review the installation process, and if all checks are passed, click "Upgrade Moodle database now".
8. Once the installation is complete, you will be taken to the plugins page, where the newly installed plugin should be listed as active.

Step 3: Configure the Plugin

1. After installation, navigate to Site administration > Plugins > Blocks > Level Up XP to configure the plugin settings.
2. For the "Badges" plugin, go to Site administration > Badges > Badge settings to configure it.
3. Inside Badge settings you configure the "Manage backpacks" option to integrate the badges earned by students with the well-known tool **Badgr.io**. By enabling this feature, students can automatically connect their Moodle-earned badges to their Badgr backpack, allowing them to display, store, and share their achievements beyond the Moodle platform.

Example 1: Setting Up Points Distribution and Levels with "Level Up XP"

1. Setting Up Points Distribution:

- Go to Site administration > Plugins > Blocks > Level Up XP.
- Under "Points settings", configure how points are awarded. For example, you can assign:
 - 10 points for completing a quiz.
 - 5 points for participating in a forum discussion.
 - 15 points for submitting an assignment.
- These settings allow you to align the point distribution with the course's learning objectives, ensuring that students are rewarded for actions that contribute significantly to their learning.

2. Creating Experience Levels:

- Navigate to the "Levels" tab within the "Level Up XP" settings.
- Define levels by setting the required points to reach each level. For instance:
 - Level 1: 0-50 points
 - Level 2: 51-100 points
 - Level 3: 101-200 points
- You can create as many levels as necessary, depending on the course length and complexity. Customise level names and descriptions to reflect milestones within the course. Every time a user levels up, a congratulatory notification will be displayed inside a pop-up window.

3. Configuring Leaderboards:

- Enable the leaderboard feature under the "Leaderboard" tab.
- Customise the display to show the top 10 students or all participants.
- You can choose whether to reset the leaderboard at specific intervals (weekly, monthly, etc.) or keep it cumulative throughout the course.

Example 2: Customizing Badges for Competency Achievement

1. Setting Up Badges:

- Go to Site administration > Badges > Manage badges.
- Click "Add a new badge".
- Name the badge according to the competency or milestone it represents, such as "Module 1 Mastery" or "Advanced Programming Competency".
- Upload an image for the badge to make it visually distinctive.

2. Defining Badge Criteria:

- Set the criteria for earning the badge. For example:
 - Require completion of all activities in a specific module.
 - Require reaching a certain level in "Level Up XP".
 - Link the badge to a specific competency framework defined in Moodle.
 - Set an expiration date for the badge if applicable, or allow it to be permanent.
- 3. Issuing and Displaying Badges:**
- Configure the badge to be issued automatically upon meeting the criteria.
 - Ensure the badge appears in the user's profile and can be exported to their digital "backpack" for sharing externally.

Remarks: Regularly review and adjust the settings to ensure they continue to align with the course's evolving needs. Monitor student engagement and make any necessary adjustments to the gamification elements, such as tweaking point values or adding new levels and badges.

B. Step-by-Step Guide to Creating a Competency Framework

To create a competency framework for the e-DIPLOMA platform in Moodle, especially considering the course content "Learn block programming and electronics" the following example can be followed. This will guide you through the process of setting up a competency-based learning system that uses gamification techniques like "Competency unlocking" and "Feedback" to enhance student engagement and progression.

Step 1: Define Competencies Based on Course Content

Start by identifying the key competencies that students should acquire by completing the course. For example, in the "Learn block programming and electronics" course, competencies could include:

1. **Understanding Basic Programming Concepts:** This could be tied to completing the theoretical lessons, such as "What's Programming All About?" and "Let's Talk Loops".
2. **Applying Programming in Practice:** Linked to the practical sessions, like "Virtual Playground: Explore BlockCoding in Virtual Reality".
3. **Understanding and Assembling Electronic Circuits:** Connected to the lessons about Arduino, sensors, and actuators, such as "Getting started: what is Arduino?" and "The role of sensors".
4. **Hands-On Experience with AR and VR:** Associated with activities like "Hands-On Assembly in Augmented Reality" and the final collaborative VR project "Collaborative Virtual Reality Codeventure".

Each competency should be clearly defined with specific learning outcomes that students are expected to achieve.

Step 2: Set Up the Competency Framework in Moodle

1. **Navigate to Competency Settings:**
 - Go to Site administration > Competencies > Competency frameworks.

- Click on "Add a new competency framework" to create a new framework for the course.
- 2. **Create the Competency Framework:**
 - Name the framework, for example, "Programming and Electronics Competency Framework".
 - Add a description to outline its purpose and the competencies it includes.
- 3. **Define Competencies:**
 - Within the framework, click on "Add a competency".
 - For each competency, such as "Understanding Basic Programming Concepts", add a detailed description, specify the course content it is linked to (e.g., Lesson 1: Theory), and set any required performance criteria.
 - Repeat this step for each competency defined earlier.
- 4. **Link Competencies to Course Modules:**
 - Go to the course page (Course administration > Competencies > Manage competencies in course).
 - Add the competencies to the relevant activities or modules. For example, link the "Understanding Basic Programming Concepts" competency to the quizzes and lessons in "Lesson 1 - Theory".
 - Set up rules for competency completion, such as requiring a specific score on the associated quizzes or completing all related activities.

Step 3: Configure Competency-Based Content Unlocking

1. **Set Up Content Unlocking:**
 - For each competency, configure Moodle to unlock the next set of content once the competency is achieved.
 - For instance, once a student completes all activities in "Lesson 1 - Theory" and achieves the competency "Understanding Basic Programming Concepts", the next section, "Lesson 2 - Practice", is unlocked.
2. **Integrate with the Gamification System:**
 - Align competency unlocking with the "Level Up XP" plugin so that earning competencies also contributes to leveling up and earning points.
 - For example, assign additional points when a student unlocks a new competency, further motivating progression through the course.

Step 4: Set Up Feedback and Notifications

1. **Configure Feedback for Competency Achievement:**
 - In the competency framework, set up feedback mechanisms to notify students when they achieve a competency. This could include a congratulatory message, a badge award (using the Moodle "Badges" plugin), or a new level in the XP system.
 - Ensure that feedback is immediate and highlights the significance of the achievement, reinforcing positive learning behavior.
2. **Display Competencies and Progress:**
 - Add a block on the course page that displays students' progress towards achieving competencies, making it easy for them to see which areas they have mastered and what is still pending.
 - Use the "Competency breakdown" report to provide detailed feedback on students' progress and areas needing improvement.

Step 5: Monitor and Adjust the Framework

1. Regularly Review Competency Achievement Data:

- Use Moodle's reporting tools to monitor how students are progressing through the competency framework.
- Identify any competencies that students are struggling to achieve and consider adjusting the associated activities or providing additional resources.

2. Refine the Framework as Needed:

- Based on student feedback and performance data, adjust the difficulty of competencies, modify the point distribution in the XP system, or add new competencies as the course evolves.

6.4.2 Integration with Virtual Reality and Augmented Reality

In the e-DIPLOMA platform, the integration of Virtual Reality (VR) and Augmented Reality (AR) has been achieved through the use of the "External Content" plugin in Moodle. In this report, when discussing gamification techniques examples with VR, it is implied that they also apply to AR to avoid redundancy. The specific module, titled "*Virtual Playground: Explore BlockCoding in Virtual Reality*", calls a custom script that interfaces with an external VR game designed to teach block programming. Here's how the integration works:

Launching the VR Game. The "External Content" module contains a button that, when clicked, opens the external VR application. If the application is not already installed, it provides an option for the user to download and install it. The system captures the ID of the authenticated Moodle user before launching the application, ensuring that progress and results are correctly attributed to the student.

Syncing VR Game Results with Moodle. Once the student completes the VR activity, the game sends data back to Moodle, such as whether the student finished the task and the score they received. This is accomplished via a custom web service called "local_newapiservices_execute_script", which updates the student's grade for the corresponding module in Moodle. This real-time synchronization ensures that the results from the VR game are accurately reflected in Moodle, allowing for seamless tracking of the student's progress.

Awarding Badges and Updating LevelUP XP. Based on the grade received from the VR activity, the system can automatically award badges or update the student's experience points (XP) using the "LevelUP XP" plugin. For example, if a student successfully completes the VR game with a high score, they may level up or earn a competency-related badge that reflects their mastery of the subject.

Notification System: Every time the script "local_newapiservices_execute_script" is executed and the student's grade is updated, a notification is automatically sent to the student using Moodle's built-in notification system. This keeps the student informed of their progress and achievements in real-time.

Automatic Enrollment for External Participants: In cases where a user participates in the VR game but has not yet been enrolled as a student in the Moodle course, the system is designed to handle this scenario automatically. When the external VR application submits the user's score via the web service, the system checks if the user exists in Moodle but is not enrolled in the course. If so, it enrolls the user in the course and assigns the grade they earned in the VR activity. This ensures that all participation in the external VR game is captured and reflected within the Moodle platform.

Gamification Through Competency-Based Rewards: The gamification elements, such as points and badges, are tied to competency acquisition. As students complete activities and demonstrate mastery of specific skills, they receive both competency recognition and gamified rewards through tools like XP or Badges. For instance, completing the VR block programming game with a high score not only grants the student the relevant competency but also contributes to their overall performance level and badge collection.

Competency Unlocking: Moodle's *Restrict Access* feature is used to unlock additional content as students achieve certain competencies. For example, once a student has completed the "*Virtual Playground: Explore BlockCoding in Virtual Reality*" module and earned the "Block Programming Mastery" competency, they might unlock the next module, such as "*Hands-On Assembly in Augmented Reality*". This creates a progressive learning pathway that motivates students to advance through the course by mastering each competency.

7. Conclusion

This work has implemented gamified solutions with the objective of increasing motivation and improving students' learning outcomes within the e-Diploma project framework. Innovative gamification techniques, validated in the scientific literature, have been employed to achieve this goal. A comprehensive reference framework for gamification in education has been proposed, combining recognized gamification perspectives with disruptive technologies such as Virtual Reality (VR) and Augmented Reality (AR). Within this framework, we have developed custom gamified immersive learning modules specifically for this research project.

The result is an integrated solution, with a gamified Moodle course as the central axis, which extends and is enhanced by the outcomes of student training in immersive gamified modules. The project integrates an educational gamified VR and AR environments that reinforces programming and electronics concepts respectively. Those approaches provide students with a multisensory learning experience that combines theory with practice. This environment allows students to immerse themselves in an interactive experience similar to a video game while learning to program. On the other hand, a gamified AR application has also been developed, enabling students to explore electronic components in real time and assemble various elements of an Arduino system. The solutions help to bridge the gap between theoretical learning and hands-on practice, offering a motivational and immersive approach that has the potential to revolutionise traditional educational models.

The framework focuses on incorporating gamification dimensions, such as performance measurement, social engagement, and personal progression, through established methods like points, experience levels, leaderboards, and badges. These elements are combined with adaptive learning paths, using novel recommender system methods, and real-world challenges, making the learning process both personalised and motivating.

While the project has made significant advances in both technical implementation and theoretical development, the next step is to implement a comprehensive validation methodology as future work. Currently, some external modules of the project, such as the educational gamified virtual reality environment and the gamified augmented reality application, will be tested by real users. At that point, longitudinal studies and performance evaluations will be conducted to help measure the framework's

effectiveness. This is especially necessary to achieve the project's educational goals. Finally, this work contributes an innovative and scalable approach to integrating advanced gamification techniques with emerging technologies in educational settings. It provides a valuable reference for future implementations of e-learning systems that aim to combine gamified novel technologies in structured learning environments.

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