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IP-ADDRESS EXPLORER

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Abstract

Understanding IP (Internet Protocol) addressing can be challenging for beginners because conventional learning approaches may provide limited interaction, while IP addressing concepts can be difficult to visualise and apply in practical situations. The complexity of IP addressing and the limited use of interactive learning activities may affect learners' understanding and engagement with networking concepts. This project aims to develop an educational game that incorporates game-based learning elements to provide an interactive and engaging approach to learning basic Internet Protocol addressing concepts, particularly the differences between public and private addresses. The project was developed using an Agile methodology consisting of planning, design, development, testing, and deployment. Unity was used as the main game development platform, supported by Visual Studio Code for programming and phpMyAdmin with Laragon for database and local server management. The game incorporates interactive environments, tasks, hints, quizzes, user authentication, and progressive levels to encourage learners to apply networking concepts through gameplay. Functional evaluation was conducted using unit testing and integration testing covering registration, login, logout, game navigation, tasks, quizzes, pause functions, and game progression. All documented test cases successfully passed, demonstrating that the implemented functions operated according to their intended requirements. The developed game provides an interactive learning environment that combines theoretical knowledge with practical problem-solving activities and may help beginners develop a clearer understanding of basic networking concepts.

Keywords; gamified learning; networking education; IP addressing; interactive learning; educational game

Introduction

Computer networking is a fundamental area of information technology education because students need to understand how devices communicate, how networks are organized, and how addressing is used to identify devices within a network. However, networking concepts can be challenging for beginners because some of the underlying processes are abstract and are often introduced through theoretical explanations and conventional exercises. Game-based learning provides an alternative approach by allowing learners to interact with learning content through challenges, feedback, and problem-solving activities. A recent scoping review found that game-based learning can support motivation, engagement, practical knowledge, and active learning in computer science education. However, the review also highlighted that game-based learning has been used more extensively for programming and computational thinking than for other areas of computer science [1].

The use of games for computer networking education has demonstrated the potential of interactive environments to support the application of networking concepts. Graham et al. developed *Cyberspace Odyssey*, a serious game that combines a three-dimensional virtual environment with practical networking and cybersecurity tasks, allowing learners to apply networking knowledge while progressing through increasingly complex challenges [2]. Rithvik et al. proposed a game-based learning-by-doing approach for teaching the OSI model, demonstrating how interactive game activities can help learners visualise and reinforce networking concepts [4]. López-Fernández et al. reported that educational games can support knowledge acquisition and motivation in computer science education, based on an evaluation involving 321 students across face-to-face and online learning formats [3]. More recent work has also applied game-based learning to computer networks and Internet topics, further indicating the suitability of interactive game environments for networking education [5].

Despite these developments, students may still experience difficulties in understanding IP addressing concepts. Woolcott and Bui [6] reported that IP addressing are foundational concepts that students often find difficult to assimilate, with IP addressing identified as one of the more challenging topics to master in introductory computer networking. In addition, Balakrishna [7] reported a decline in student attendance and engagement in an introductory computer networking and security module, with students expressing dissatisfaction with lecture-based teaching and a preference for hands-on and practical learning activities. These findings highlight the need for learning approaches that provide students with opportunities to interact with, visualise, and apply networking concepts through practical and engaging activities. Therefore, there remains an opportunity for a learning tool that focuses specifically on basic IP addressing concepts, particularly the identification and classification of public and private IP addresses.

Therefore, *IP Address Explorer* was developed as an interactive educational game to provide learners with a focused environment for learning and applying basic IP addressing concepts. The project aims to support

understanding through structured tasks, hints, quizzes, user progression, and interactive gameplay. The game was developed using an iterative approach with Unity as the main game development platform, supported by programming and database technologies for user management and game progression. The proposed project contributes a practical supplementary learning tool that connects networking theory with interactive problem-solving and may provide a more engaging approach for beginners learning fundamental IP addressing concepts.

Methodology

a) System Design and Development

IP Address Explorer was developed using an Agile methodology comprising five main activities: planning, design, development, testing, and deployment. The planning stage focused on defining the project scope, prioritizing features, and identifying the learning and system requirements. During the design stage, the game architecture, user interface, and database structure were prepared to ensure that the system was organized and aligned with the identified requirements. The use of an iterative development approach is appropriate for educational games because game-based learning requires interaction between learning content, gameplay, and user engagement, which can be progressively refined during development [1], [2].

The main functional requirements included user registration and authentication, educational questions, challenge-based activities, hints and guidelines, and progressive game levels. The game was designed to allow players to read instructions, complete IP-address-related questions, and progress through the game sequentially. These design elements are consistent with previous networking education games that use interactive tasks and challenges to allow learners to apply networking concepts rather than relying solely on theoretical instruction [2], [4]. Game-based learning has also been reported as a potential approach for supporting knowledge acquisition and learner motivation in computer science education [3], while recent work continues to demonstrate its application to computer networks and Internet education [5].

The development was implemented using Unity as the main game development platform and Visual Studio Code for programming, code editing, and debugging. phpMyAdmin was used to manage the game database, while Laragon supported local database and server testing. Canva was used to prepare the game interface design. The prototype was developed and configured on a laptop running Windows 11 with an AMD Ryzen 3 5300U processor, 8 GB RAM, AMD Radeon graphics, and 128 GB storage. The development stage involved implementing the gameplay functions, user authentication, database interaction, educational tasks, quizzes, hints, and level progression. The testing stage was then used to identify functional issues and verify that the implemented features satisfied their expected acceptance criteria. Finally, the deployment stage involved preparing the completed game for end-user installation and use.

User → Registration/Login → Homepage → Task/Guideline → Interactive Quiz/Challenge → Complete Level → Next Level → Logout

Figure 1. IP Address Explorer system flow.



Figure 2. Account Register and Login Interface and Level Selection Interface



Figure 3. Example of Game Interface Level



Figure 4. Example of Task Interface and Hint Interface

b) Testing and Evaluation

The completed game was evaluated using unit testing and integration testing. Unit testing examined individual functions of the game, while integration testing evaluated whether the main functions operated correctly when combined within the complete system. The acceptance criterion for each test case was based on whether the actual tester result matched the expected result specified in the test plan. A total of seven units test cases were documented. These covered registration, login, logout, task information, quiz interaction, game sequence, and the homepage start button. The test conditions included providing valid registration information, using registered credentials for login, accessing the required task or quiz, completing the required level, and logging in before starting the game. All seven units test cases were recorded as Pass. Integration testing consisted of another seven test cases covering registration, login, logout, homepage start button, quiz, pause function, and game sequence. The tests evaluated whether these functions operated correctly within the integrated game environment. For example, the quiz test required the player to interact with the PC, laptop, router, and printer elements, while the game-sequence test required completion of each level before progressing to the next level. All seven integration test cases were recorded as Pass.

Table 1. Summary of Functional Evaluation

Testing type	No of test cases	Passed	Failed	Pass rate
Unit testing	7	7	0	100%
Integration testing	7	7	0	100%
Total	14	14	0	100%

The evaluation therefore focused primarily on functional correctness and system integration, rather than quantitative measurements such as learning-gain percentage, response time, or network performance. It does not have repeated trials for each test case; therefore, the 100% result represents the 14 documented test cases, rather than a statistical accuracy measurement. This functional evaluation approach is appropriate as an initial verification of an educational game, while previous game-based learning research demonstrates the value of further evaluating learning outcomes and motivation [1][3].

Results and Discussion

The results presented in Table 1 demonstrate that it is important in relation to the project objective of developing an interactive learning environment for fundamental IP addressing concepts. The successful operation of the registration and login functions supports controlled access to the game, while the task, quiz, and game-sequence functions provide the intended interactive learning structure. The progressive game sequence is particularly relevant because players are required to complete each level before proceeding to the next stage. The results are also consistent with the potential of game-based approaches reported in previous studies. One of the strengths of the developed project is the integration of educational content with interactive gameplay. Instead of presenting networking information only through conventional text, the game provides tasks and quiz activities that require users to interact with networking-related objects and progress through levels. The developed game also identifies the combination of interactive gaming, instructional content, hands-on exploration, and problem-solving as key features of the developed learning environment.

However, the evaluation has several limitations. Firstly, the reported testing focused on functional correctness and system integration, rather than measuring actual improvement in learners' knowledge. Therefore, the 100% result should be interpreted as a 100% functional test-case pass rate, not as 100% learning accuracy or educational effectiveness. Secondly, the developed game does not provide repeated trials, response-time measurements, learning-gain scores, or user satisfaction data. Consequently, these parameters cannot be used to make quantitative claims about the effectiveness of the game. The report also identifies limitations related to the difficulty of providing up-to-date IP information and the challenges beginners may face when interpreting networking information. Overall, the results demonstrate that IP Address Explorer functioned successfully

according to the documented functional and integration test specifications, with all 14 evaluated test cases passing. The project therefore demonstrates technical feasibility as an interactive networking learning tool. Future evaluation should include actual learners and measure learning improvement through pre-test and post-test assessments, together with usability and user-satisfaction evaluation. The game could also be enhanced with character customisation, leaderboards, and multiplayer features, to provide additional engagement and motivation.

Conclusion

IP Address Explorer was successfully developed as an interactive educational game for introducing fundamental IP addressing concepts through tasks, quizzes, hints, and progressive gameplay. The project achieved its intended technical objectives by implementing the required user authentication, learning activities, game navigation, and level progression functions. Functional evaluation demonstrated that the developed system operated according to the documented requirements, with all tested unit and integration functions successfully passing their respective test cases. The project therefore demonstrates the feasibility of using an interactive game environment as a supplementary tool for learning basic networking concepts.

Despite achieving the intended functional requirements, the project evaluation was limited to functional and integration testing and did not measure learning improvement, user satisfaction, response time, or learning effectiveness among actual users. Future improvements could include conducting pre-test and post-test evaluations with students, incorporating usability and user-satisfaction assessments, and expanding the game with additional interactive features such as character customization, leaderboards, and multiplayer functionality. These enhancements could further improve the learning experience and provide stronger evidence of the project's educational effectiveness.

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