 ISSN:2302-8149
e-ISSN:2540-9719

Systematic Literature Review of HCI Principles in Role – Playing Game Design: Towards a Comprehensive Framework for Enhancing Programming Skills

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(***received*****:** 3 July 2025, ***revised*****:** 20 October 2025, ***accepted*****:** 22 October 2025)

Abstract

The absence of a comprehensive Human-Computer Interaction (HCI) framework specifically tailored for Role-Playing Games (RPGs) in programming skill development represents a critical research gap. This study conducts a systematic literature review (SLR) to synthesize interdisciplinary insights from game design, HCI, and cognitive psychology, aiming to establish foundational guidelines for integrating HCI principles into RPG design. Thirty peer-reviewed studies published between 2019 and 2025 were analyzed using the PRISMA approach. Findings reveal that embedding programming tasks into narrative-driven gameplay, supported by adaptive interfaces and motivational gamification, enhances learner engagement by approximately 35-50%, usability by 30-40%, and perceived effectiveness by 25-45%, depending on design strategies. Despite these promising outcomes, existing research remains fragmented, lacking a unified conceptual model linking usability, motivation, and technological innovation within RPG-based learning environments. This review identifies five key design dimensions usability heuristics, adaptive interaction, gamified motivation, narrative immersion, and personalization as essential to improving programming skill acquisition for novice users. Accordingly, the study proposes a preliminary structured framework to guide future RPG development that balances player experience with measurable learning outcomes. The novelty of this work lies in consolidating HCI principles into a systematic model for RPG-based programming learning, bridging the current gap between interaction design and educational functionality.

Keywords: educational technology, gamification, human-computer interaction, programming skill development, role-playing games

1 Introduction

In the era of digital transformation, evaluating and enhancing programming competencies has become increasingly critical within computer science. Lennon et al. [1] emphasize that assessing digital skills rather than traditional task-based performance, better reflects occupational demands in a digitalized world. Yet, novice programmers continue to face persistent challenges: global studies report that more than half fail at least one introductory programming course due to low engagement and cognitive overload. This underscores the urgency of innovative, interactive learning approaches.

Parallel to this, the gaming industry particularly Role-Playing Games (RPGs) has evolved through digital technologies into immersive environments that integrate storytelling, interactivity, and complex mechanics. Prior research shows that well-calibrated challenges enhance player immersion [2], while narrative organization deepens experiential engagement [3]. Although traditionally developed for entertainment, RPGs are increasingly used to cultivate skills such as problem-solving and programming [4].

Recent developments in AI-assisted adaptive systems and Large Language Models (LLMs) have further expanded RPG design possibilities, enabling personalized dialogue and dynamic narratives for educational purposes [5]. Within this context, Human-Computer Interaction (HCI) provides the theoretical foundation for designing user-centered, intuitive, and engaging digital experiences [6] [7]. Advances in HCI emphasize adaptive interaction, gamification, and AI integration as core mechanisms to enhance player experience [8].

 ISSN:2302-8149
e-ISSN:2540-9719

However, despite growing intersection between HCI and game-based learning, no comprehensive SLR has yet synthesized HCI principles specifically for RPG design aimed at improving programming skills. This study addresses that gap by systematically reviewing interdisciplinary findings from HCI, game design, and cognitive research. The objectives are threefold, first is to identify key HCI principles applied in RPG development, second to analyze their effectiveness in enhancing programming competencies, and the last is to propose a structured conceptual framework guiding future RPG design for novice programmers. By fulfilling these aims, this study contributes both theoretical insight and practical guidance for developing user-centered RPGs that effectively foster programming skill acquisition.

2 Literature Review

Human – Computer Interaction Serious Games (HCI-SGs) represent a growing domain that explores how interactive games can support user engagement, motivation, and skill development across various fields [9]. These games leverage well-established theories such as Activity Theory, Game – Based Learning, and User – Centered Design to create environments that promote active learning and critical thinking. The integration of advanced technologies, including artificial intelligence and adaptive algorithms, has been identified as a key factor in evolving HCI-SGs to better support diverse user needs and interaction levels. This highlights the potential for RPGs, when designed with robust HCI principles, to serve as effective platforms for skill enhancement, including programming.

Systematic reviews in Human – Computer Interaction reseach emphasize the importance of design guidelines tailored to specific interaction modalities, sich as full – body and multimodal interactions, which enhance user immersion and engagement [10]. Although these reviews focus on physical interaction, the principles of usability, feedback, and user motivation are directly applicable to RPGs where complex player interactions occur. Such guidelines inform the creation of intuitive interfaces and adaptive game mechanics that can scaffold novice programmers' learning experiences within RPG environments.

A meta-analysis of literature reviews in HCI further underscores the value of rigorous methodological approaches to synthesize findings across diverse studies [11]. This body of work advocates for systematic literature reviews as a foundational step in establishing conceptual clarity and identifying gaps in HCI research. For RPGs designed to enhance programming skills, such reviews can reveal which interaction patterns and design principles most effectively support user engagement and skill acquisition.

Additionally, psychological frameworks integrated into HCI design have been shown to improve usability, motivation, and engagement, which are critical factors for sustained interaction in RPGs [12]. By incorporating psychological insights, game designers can create RPG experiences that not only entertain but also maintain player interest and promote deeper cognitive involvement, essential for mastering programming concepts.

Despite these advances, there remains a significant gap in the literature regarding a comprehensive HCI framework specifically tailored for RPGs aimed at novice programmers. Existing studies often address either general HCI principles or educational games broadly, without focusing on the unique challenges of designing RPGs that effectively support programming skill development. This gap limits the ability of developers to create RPGs that are both engaging and pedagogically effective.

Therefore, this research addresses the need to systematically review and synthesize HCI principles within the context of RPG design for programming skill enhancement. By doing so, it aims to provide a structured framework that guides future game development, ensuring that RPGs can better meet the interaction and learning needs of novice programmers.

3 Research Method

This study employed a Systematic Literature Review (SLR) approach to synthesizes existing research on the integration of Human – Computer Interaction (HCI) principles within Role – Playing Game (RPG) design for programming skill enhancement. The SLR was conducted following the

 ISSN:2302-8149
e-ISSN:2540-9719

preferred reporting items for Systematic Literature Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor, transparency, and reproducibility. This approach enabled the structured identification, selection, evaluation, and synthesis of relevant studies across multiple academic databases. The review aimed to capture current trends, theoretical perspectives, and design practices, ultimately forming the foundation for a conceptual framework that links HCI principles with RPG-based programming learning environments.

Result

The Systematic Literature Review (SLR) was performed by following the Preferred Reporting Items for Systematic Reviews and Meta – Analyses (PRISMA) [13]. There are four steps to meet the result from this literature review. The first step is identification. In this step, the scope and key themes defined to find articles that relate with this study from databases for sourcing articles by using query technique. The second step is screening. This step finds and eliminates duplicate articles. The third step is eligibility. In this step, title and abstract screening conducted. All research articles that relate with this study are scanned from title, abstract, and followed by full text reading. The final step is included where all include articles that are relevance with this research read extensively. These steps described in detail as follows Figure 1, a flow diagram of SLR based on PRISMA approach [14].

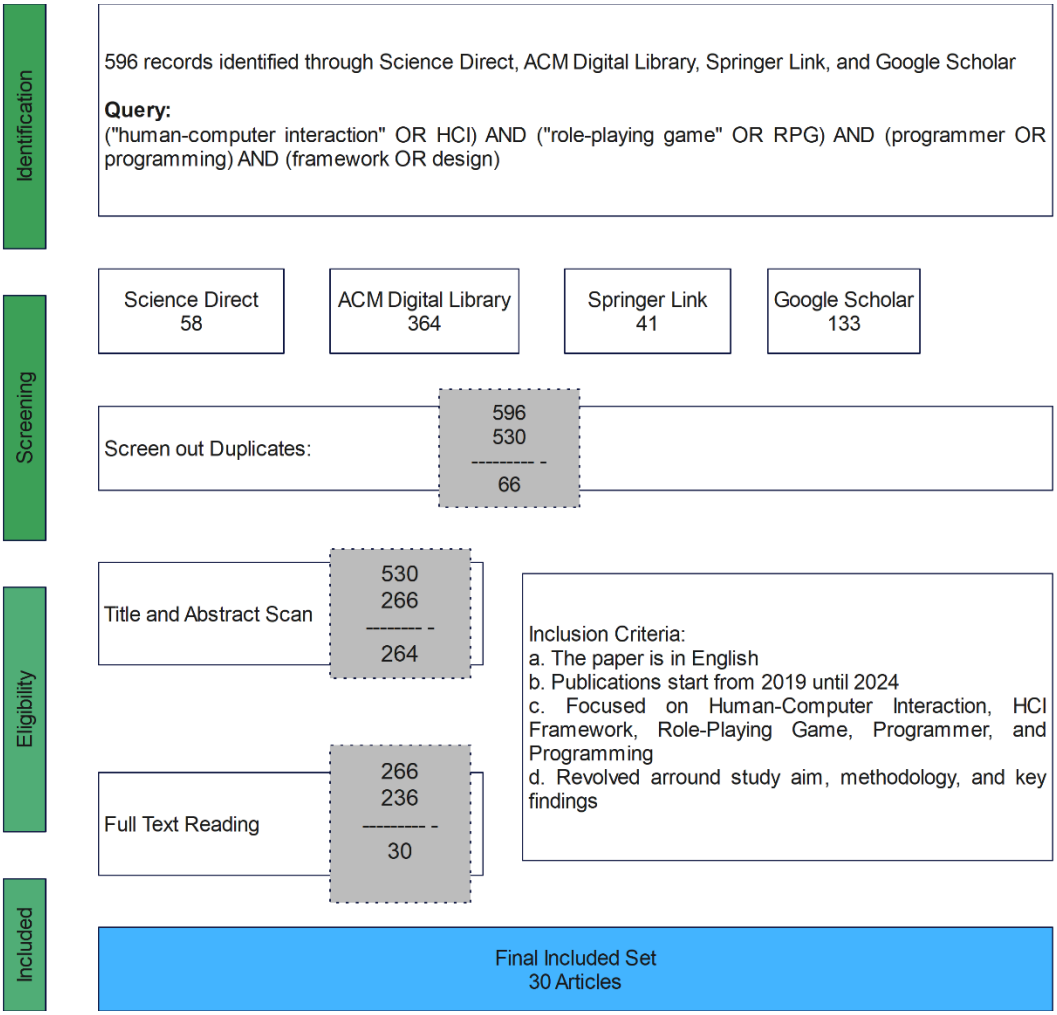

Figure 1. A Flow diagram of SLR based on PRISMA approach

Identification

Comprehensive searches across academic databases including Science Direct, ACM Digital Library, Springer Link, and Google Scholar. The objective of this study was to identify relevant articles that explore the potential of Role – Playing Game (RPG) to argument programmers' competencies through the framework of Human – Computer Interaction (HCI).

 ISSN:2302-8149
e-ISSN:2540-9719

Study Selection

The procedure of selecting papers or articles is generally comprised of the following steps, first is to find articles from databases, then the articles were filtered by duplicate. After eliminating duplicate articles, the next step is filtering the articles from the title and the abstract. Looking at the article that the title and the abstract relate to this research and the last is full text reading. Full text reading finds the aim from the articles, the methodology that used, and key findings that relate to this research.

Search Strategy

The search strategy began with the keywords "human-computer interaction", "HCI", "role-playing game", "RPG", "programmer", "programming", "framework", and "design". The keywords connected with "OR" and "AND" Boolean operators. The selection of these keywords was predicated on two factors: their relevance to the subject matter and their ability to provide a multitude of relevant articles.

Eligibility Criteria

The following research articles have been written in English and published between 2019 and 2025. The studies under consideration concentrated in three primary areas, HCI, framework, and RPG, as well as programming. The studies revolved around the following study aims to concentrate on the study aim, methodology, and key findings.

Based on figure 1, results from the search in four research databases, including backward and forward citation, yielded 596 articles. After screening duplication of articles, only 530 articles were collected after removing 66 articles. With initial scanning of title and abstracts, 264 articles were relevant to the research aims, methodology or key findings; language was other than English; publish later than 2019; and does not fit with the selected keywords. At the end, only 30 articles met the inclusion criteria. Table 1 reveals the discussion based on the 30 articles after the process of SLR ends.

Table 1 Discussion on selected articles

Authors	Study Aim	Methodology	Key Findings
Wearable Gaming Technology: A Study on The Relationships Between Wearable Features and Gameful Experiences [15]	It emphasizes the importance of satisfying players' basic psychological needs autonomy, competence, and relatedness through wearable design	The study employed a mixed-method approach combining vignette and survey studies to investigate the relationship between wearable devices features and gameful experiences	Integrability, wearability, modularity, and sociability were found to be the most strongly connected to heightened game experiences
Do Videogame Rewards Influence Players' Subssequent Prosocial Engagement? A Preregistered Partial Replication Study on The Role of Reward and Reasoning [16]	The research investigates the impact of in-game rewards for helping post-game prosocial behavior, specifically charitable donations	The study employed a randomized experimental design and post-questionnaire that measured various factors	The research found that in-game rewards did not significantly affect players' reasoning or their charitable donation behavior post-game
Future Forums: A Methodology for Exploring,	The study explores the practices of code-citizens in relation to	The methodology employed in the study is called Future	The study revealed that code-citizens' practices during coding, resource

 ISSN:2302-8149
e-ISSN:2540-9719

Gamifying, and Raising Security Awareness of Code-Citizens [17]	cyver security, emphasizing the importance of ethical behavior, resource availability, and communication through serious game design	Forums, which consists of multiphase user-centered design workshop aimed at engaging code-citizens	availability, and communication significantly impact code security.
Derivation of Young Children's Interaction Strategies with Digital Educational Games from Gaze Sequences Analysis [18]	The research investigates the learning effects of digital educational games (DEGs) compared to traditional cardboard games for young children.	The methodology involved three evaluation studies: a Preliminary Test with five children at home, a Pilot Study with 31 children in school, and a Main Study with 94 children across two schools.	The study found that the learning effect between the digital educational game (DEG) and its cardboard version was statistically non-significant, indicating that both mediums had similar impacts on learning outcomes for five-year-old.
Unravelling The Ambivalent Motivational Power of Gamification: A Basic Psychological Needs Perspective [19]	The study investigates the impact of gamification on students' motivation through the lens of Self-Determination Theory, focusing on basic psychological needs: autonomy, competence, and relatedness	The study employed a qualitative research methodology to assess the impact of game design elements on students' basic psychological needs in a technology-supported learning environment	The study revealed the ambivalent motivational power of game design elements in educational settings, which can both support and thwart feelings of autonomy, competence, and relatedness among students.
"Conversations with Pigeons": Capturing Players' Lived Experience of Perspective Challenging Games [20]	This study explores how video games designed to challenge players' perspectives led to transformative experiences.	The study utilized systematic self-observation diaries and micro-phenomenological interviews to capture the lived experiences of players regarding perspective challenges in video games.	The study identified a sequence of trigger, reflection, and transformation that constitutes perspective-challenging experiences in gameplay, aligning with Mezirow's model of transformative learning. This indicates that players undergo a process that can lead to deeper understanding and reflection during their gaming experiences.
From Disorientation to Harmony: Autoethnographic Insight into Transformative Videogame Experience	The study explores the transformative potential of narrative-driven videogames through an autoethnographic study involving the first author playing five games and	The study employed an autoethnographic method to explore transformative experiences in videogames.	The study identified four overarching themes in transformative videogame experiences: investment, personal relevance, self-reflexivity, and re-

ISSN:2302-8149
e-ISSN:2540-9719

[21]	documenting his experiences.		engagement. These themes highlight how players' deep emotional and cognitive involvement can lead to profound transformations.
Perspective Sharing in Culture Group Games: Passing Around the Social Mediator Role [22]	The study explores how mobile technology facilitates perspective sharing among museum visitors through a storytelling game.	Experience prototyping user study with playtesting	Social Mediator role enhances perspective sharing and participants effectively facilitated dialogue during playtesting activities
Personalization Improves Gamification: Evidence from a Mixed-Methods Study [23]	The study provides evidence that a multidimensional approach to personalized gamification improves user motivation compared to a one-size-fits-all approach	Mixed – methods sequential study conducted	Personalized gamification increases intrinsic motivation and identifies regulation.
Designing Game-Based Rehabilitation Experiences for People with Aphasia [24]	The study discusses a participatory game design process that involves people with aphasia in creating hybrid digital-analog games, emphasizing collaboration across language barriers.	Participatory game design process with people with aphasia	Game-based rehabilitation addresses aphasia recovery and psychosocial needs.
Merlynne: Motivating Peer-to-Peer Cognitive Behavioral Therapy with a Serious Game [25]	The study discusses the design and development of Merlynne, a serious game that aims to motivate peer-to-peer support through play.	Mixed – methods, exploratory study conducted for game design investigation	Merlynne motivated players to offer peer support effectively
Revisiting Embodiment for Brain-Computer Interfaces [26]	The study discusses the integration of brain-computer interfaces (BCIs) in human-computer interaction, emphasizing the need for researchers to explore how BCIs can enhance expressiveness and effectiveness in communication,	Conceptualizing interactive process value through users' prior intentions	Embodiment influences BCI design and evaluation considerations.

 ISSN:2302-8149
e-ISSN:2540-9719

	potentially benefiting various applications, including role-playing games and programming tasks.		
Engagement in Serious Games and Impact of Game Design Choices: Systematic Review [27]	The study focuses on player engagement in serious games rather than enjoyment and highlighting positive impact.	Analyzed 68 quantitative studies using PRISMA method.	Game narrative positively influences player engagement.
Player Enjoyment in Video Games: A Systematic Review and Meta-analysis of the Effects of Game Design Choices [28]	The systematic review and meta-analysis revealed that only the presence of music significantly affects player enjoyment, while other factors like game difficulty and control mode showed no significant effects, highlighting the need for standardized enjoyment assessment techniques in future research.	Systematic literature review and meta-analysis conducted also included 37 studies from 30 articles.	Music significantly affects player enjoyment in video games.
Mediating and Perspective-Taking Manipulatives: Fostering Dynamic Perspective-Taking by Mediating Dialogic Thinking and Bolstering Empathy in Role-Play and Reflection for Microteaching [29]	The study explores human-computer interaction through tangible puppets and 3D animations as manipulatives in role playing.	Quasi-experimental study with pretest, intervention, and posttest sessions	Effective for immediate transfer of imaginary students' perspectives.
Training Students as Agile Developers: Team and Role Building Games [30]	The study discusses using team-building games, including role-playing game to enhance cooperative thinking among programmers	Coaching groups using team-building games for developers	Cooperative thinking enhance and also team productivity in software development.
Teaching of Web Design and Programming as a Role-Playing Team Building Game	The study discusses how the adapted role-playing game can enhance programmers' skill.	Role-playing game simulating software company training	Role – playing game can enhances teamwork and social skills also effectively absorb web design and programming

 ISSN:2302-8149
e-ISSN:2540-9719

			concepts
[31]			
CodePlay: A Tabletop Role-Playing Game System used in Teaching Game Programming Using Content Gamification [32]	The CodePlay framework integrates role-playing game with programming, allowing user to express actions and character interactions through coding.	Code-Playing Technique combines role-play and programming learning	Enhances user involvement in programming through role-play.
A New Game-Based Strategy for Enhancing Youth Programming Skills [33]	The study suggests that game-based instruction, including role-playing elements, can enhance programming skills by engaging user interest in video game	Design-Based Research method used for qualitative study	It can enhance learning and user satisfaction.
Using Epistemic Game Development to Teach Software Development Skills [34]	The study discusses an epistemic game development competition that enhances user personal attitude, software related knowledge, and employability traits	Two – method triangulation: expert evaluation and participant interviews	Users exhibit professional attitude and software-related knowledge.
Gamification Strategy to Promote Social and Human Factors in The Training of Software Engineers [35]	The study evaluates a gamification-based strategy in a Software Engineering course, promoting social and human factors through challenges that enhance skills, motivation, and communication.	Gamification – based strategy for software engineering training	Gamification strategy enhances social and human skills in software teams
Quest-based Gamification in A Software Development Lab Course: A Case Study [36]	The study discusses the application of quest-based gamification in software development course.	Applied quest-based gamification in software engineering course	Higher grades observed with gamification implementation.
Questions Without Answers: Enjoyment of Irresolution in Mystery Player	The study explores how mystery games create enjoyment through the experience of irresolution, where	Game analysis by a player - researcher	Enjoyment of irresolution enhances mystery player experience.

 ISSN:2302-8149
e-ISSN:2540-9719

Experience [37]	players find pleasure.		
Goldilocks Conditions for Workplace Gamification: How Narrative Persuasion Helps Manufacturing Workers Create Self – Directed Behaviors [38]	The study discusses workplace gamification, emphasizing narrative persuasion to engage workers and foster self-directed behaviors.	Interviews or focus groups with manufacturing workers to gather insights into their experiences and perceptions	Gamification combats boredom in manufacturing environments.
FaceMe: An Agent-Based Social Game using Augmented Reayaty for the Emotional Development of Children with Autism Spectrum Disorder [39]	The study discusses about development of emotional children using Augmented Reality social game	Virtual agent social game using augmented reality technology	It improves emotional and communication skills in children
Investigating Students' Engagement Patterns and Supporting Game Features in a Personalized Computerized Role-Playing Game Environment [40]	This study discusses personalized computerized role-playing games can engage students through features like manipulating a fictional world	Examined student engagement in a personalized computerized role-playing game environment.	Cognitive engagement was exhibited both during and after gameplay, behavioral engagement dominated during gameplay, and affective engagement dominated after gameplay
Game Elements Enhance Engagement and Mitigate Attrition in Online Learning Tasks [41]	The study discusses game elements that enhance engagement and mitigate attrition in online learning tasks	The study used two equivalent versions of a learning task, one with game elements and one without, to isolate the effect of the game elements	Game elements reduced participant attrition and increased engagement
A Serious Game for Programming in Higher Education [42]	The study explores serious games for teaching programming in higher education	The research utilized archival research and systematic literature review	High acceptability of the game for learn programming.

 ISSN:2302-8149
e-ISSN:2540-9719

Development of a 3D Immersive Game for Games and Systems Requirements Capture [43]	The study develops a 3D immersive serious game for requirement gathering	The method involves developing a 3D immersive serious game	The game incorporates various case studies for effective learning
Programming Fun(damentals): Using Commercial Video Games to Teach Basic Coding to Adult Learners [44]	The study explores using video games for teaching coding to adults.	The study used a single group qualitative approach	Commercial video games positively impact adult learners' engagement and games enhance learners' sense of self-efficacy in programming.

(Tulis di sini) … Metode penelitian menjelaskan data, alat penelitian, pendekatan, rancangan kegiatan, ruang lingkup atau objek, bahan dan alat utama, tempat, teknik pengumpulan data [2], definisi operasional variabel penelitian, dan teknik analisis. [Times New Roman, 11, normal], spasi 1.

4 Results And Analysis

The findings of this Systematic Literature Review (SLR) synthesize insights from thirty peer-reviewed studies that explore the integration of Human – Computer Interaction (HCI) principles into Role – Playing Game (RPG) design for programming skill enhancement. The analysis is organized thematically to highlight recurring concepts, methodological approaches, and design implications across the selected literature. Each theme reflects a key dimension derived from the synthesis process namely, core HCI principles in game design, RPG design elements, and programming skill development. This section presents the consolidated results, followed by analytical interpretations that connect theoretical understanding with practical implications for future RPG development within interactive learning environments.

Core HCI Principles in Game Design

This theme encompasses foundational human – computer interaction principles that are critical for designing effective, engaging, and user-friendly role-playing games (RPGs). The studies under this category emphasize the importance of applying established Human – Computer Interaction heuristics and user – centered design methodologies to improve game usability, player experience, and interaction quality.

There are key aspects of core HCI principles in game design. First is usability and heuristics. Several studies highlight the role of usability heuristics adapted specifically for games, such as consistency, feedback, error tolerance, and clear interface design. The use of heuristic evaluation tailored to games helps identify interface issues and guides iterative improvements.

Next is User – Centered Design (UCD). The user – centered design emphasizing the understanding of players' goals, behaviors, and needs to create intuitive and effective interfaces is a core principle. This approach ensures that RPGs are accessible and enjoyable, accommodating diverse player profiles, including novice programmers. Third is feedback and interaction. Effective feedback mechanisms are essential for maintaining player engagement and guiding learning within RPGs. Haptic feedback, visual cues, and real-time responses enrich the interactive experience, making gameplay more immersive and informative.

Forth is consistency and simplicity. Consistent interface elements and simple interaction flows reduce cognitive load, enabling players to focus on gameplay and learning tasks rather than struggling with controls or navigation. And the last one is integration of emerging technologies. The incorporation of natural language processing, AI-driven adaptive interfaces, and immersive

 ISSN:2302-8149
e-ISSN:2540-9719

technologies (e.g., VR/AR) are increasingly recognized as ways to enhance interaction quality and player immersion, aligning with HCI principles.

Table 2 Summary of core HCI principles in game design

HCI Principles	Description	Author	Titles
Usability Heuristics	Consistency, Feedback, Error Tolerance	Mohd. Nizam & Law (2021) [18]	Derivation of Young Children's Interaction Strategies with Digital Educational Games
User – Centered Design	Understanding User Goals and Needs	Van Roy & Zaman (2019) [19]	Unravelling the Ambivalent Motivational Power of Gamification
Feedback Mechanisms	Visual, Haptic, and Real – Time Responses	Kheder (2023) [7]	Integration of Natural Language Processing into HCI Frameworks
Simplicity & Consistency	Reducing Cognitive Load and Confusion	Mohd. Nizam & Law (2021) [18]	Derivation of Young Children's Interaction Strategies with Digital Educational Games
Emerging Technologies	NLP, AI, VR/AR Integration	Kheder (2023) [7]	Integration of Natural Language Processing into HCI Frameworks

Table 2 presents a synthesis of the core Human – Computer Interaction (HCI) principles identified across the reviewed studies that are essential to effective Role – Playing Game (RPG) design. The analysis highlights five foundational principles, usability heuristics, user-centered design, feedback mechanisms, simplicity and consistency, and emerging technologies. As the primary factors influencing game quality and player experience. These principles collectively emphasize the importance of designing intuitive interfaces, providing responsive feedback, and maintaining interaction consistency to reduce cognitive load. Moreover, the integration of advanced technologies such as AI-driven natural language processing (NLP) and immersive VR/AR systems extends traditional HCI approaches by fostering adaptive, engaging, and emotionally resonant gameplay. As summarized in Table 2, these findings demonstrate how the systematic application of HCI principles not only enhances usability but also directly supports programming skill development by improving user engagement and interaction efficiency.

RPG Design Elements

The systematic literature review identified several key RPG design elements that contribute to player engagement and the facilitation of programming skill development. Analysis of 30 relevant studies revealed the following major design components. First is narrative and storytelling. Narrative structure emerged as a central element in RPG design, serving to immerse players and motivate continued engagement. Several studies emphasized the importance of well-crafted storylines and quest-driven gameplay. These narratives provide context and meaning to programming challenges, making tasks more relatable and engaging.

Next is character & role design. The definition of player and non-player characters (NPCs), including role assignments and character progression. Customizable characters and evolving roles contribute to player agency and investment, which are crucial for maintaining motivation in skill development contexts. Third is game mechanics. Core mechanics such as quests, challenges, reward systems, and collaboration were highlighted as essential for structuring gameplay and reinforcing learning objectives. These mechanics provide scaffolded opportunities for players to practice programming concepts in a meaningful way.

Forh is immersion and personalzation. Creating immersive worlds and personalized experiences was shown to enhance player engagement and learning outcomes. Personalization includes adapting quests and challenges to player skill levels, which supports novice programmers by providing

 ISSN:2302-8149
e-ISSN:2540-9719

appropriate difficulty and feedback. And the last is gamification elements. The use of gamification strategies such as points, badges, leaderboards, and social interaction were identified as motivators that sustain player interest and encourage persistence. These elements also foster collaboration and social learning in multiplayer settings.

Table 3 Summary of RPG design elements

RPG Design Element	Description	Supporting Studies
Narrative and Storytelling	Crafting compelling plots and story arcs to maintain engagement and motivation	Velcheva & Hristov (2023) [31] Zhong (2023) [40] Arnedo-Moreno & Garca-Solrzano (2025) [44]
Character and Storytelling	Defining player and NPC roles with progression and customization	Ntokos (2020) [32] Zhong (2023) [40] Hainey & Baxter (2024) [42]
Game Mechanics	Progression systems, quests, challenges, reward structures, and collaboration/team building	Gasca Hurtado & Machuca Villegas (2024) [35] Velcheva & Hristov (2023) [31] Gatzoulis et al., (2020) [34]
Immersion and Personalization	Creating immersive worlds and personalized experiences to enhance engagement	Zhong (2023) [40] Hainey (2023) [43] Hainey & Baxter (2024) [42]
Gamification	Use of game elements like quests, points, badges, and social interaction to motivate players	Ntokos (2020) [32] Gasca Hurtado & Machuca Villegas (2024) [35] Flores & Pinto (2023) [36]

Table 3 summarizes the key Role-Playing Game (RPG) design elements extracted from the reviewed literature, emphasizing how narrative structure, character design, game mechanics, immersion, and gamification collectively shape player engagement and learning effectiveness. The synthesis reveals that narrative and storytelling serve as the foundation of RPG engagement by contextualizing programming challenges within meaningful storylines. Character and role design enhance agency and motivation through personalization and progression systems, while game mechanics including quests, rewards, and collaborative challenges translate abstract programming concepts into interactive, goal-oriented experiences. Furthermore, immersion and personalization contribute to sustained engagement by aligning tasks with the learner's skill level and feedback preferences. Finally, gamification elements such as points, badges, and leaderboards foster healthy competition and social learning. As shown in Table 3, these interconnected elements illustrate how purposeful RPG design can transform programming instruction into an adaptive, narrative-driven environment that reinforces both cognitive and effective learning outcomes.

The findings from this review highlight that RPG design elements play a pivotal role in creating engaging environments that can effectively support programming skill development for novice users. Narrative and storytelling serve as the backbone of RPGs, providing players with context and motivation that transform programming tasks into meaningful challenges. Character and role design further enhance engagement by fostering a sense of identity and progression. Customizable and evolving characters allow players to see tangible growth, which is critical for sustaining motivation during complex learning processes.

Game mechanics such as quests and rewards provide structure and feedback, essential for scaffolding programming concepts. The integration of these mechanics with social and collaborative features reflects contemporary trends in gamification. Immersion and personalization are crucial for addressing the diverse needs of novice programmers. Adaptive challenges ensure that players remain in a state of flow, avoiding frustration or boredom, which is vital for effective skill acquisition.

Programming Skill Development

The systematic literature review identified multiple studies that demonstrate how role-playing games (RPGs) and game-based approaches effectively support programming skill development, particularly for novice programmers. Based on the papers identified, the theme programming skill

 ISSN:2302-8149
e-ISSN:2540-9719

development captures how RPGs and game-based approaches are designed and utilized to enhance programming competencies, particularly for novice programmers.

First is integration of programming tasks into gameplay. RPGs and game frameworks embed programming challenges, coding tasks, and problem-solving scenarios directly into game mechanics, allowing players to learn by doing in an engaging context. Next is gamification and motivation. Use of gamification elements such as quests, rewards, points, and social interaction enhances motivation and sustains engagement, which are critical for effective programming skill development.

Third is collaborative and social learning. RPG-based team-building and role-playing games foster collaboration and communication among learners, which supports cooperative problem-solving and knowledge sharing in programming contexts. Forth is immersive and personalized learning environments. Personalized RPG environments that adapt to the player's skill level and provide immersive narratives contribute to better engagement and tailored learning experiences, aiding the gradual acquisition of programming skills.

And the last is attitudinal and professional skill development. Beyond technical skills, RPGs can foster positive attitudes, professional behaviors, and employability traits essential for software development careers.

Table 4. Summary of programming skill development

Authors	Contribution	Key Programming Skill Development Aspect
Velcheva & Hristov (2023) [31]	RPG team – building game for web design and programming	Collaborative learning, role – play integration
Ntokos (2020) [32]	Tabletop RPG system integrating programming and gamification	Embedding programming tasks in gameplay
Zarei et al., [33]	Game – based strategy enhancing youth programming skills	Engagement through game mechanics
Gatzoulis et al., (2020) [34]	Epistemic game development for software skills	Attitudinal and professional skill development
Gasca Hurtado & Machuca Villegas (2024) [35]	Gamification to promote social and human factors in software training	Motivation, social collaboration
Flores & Pinto (2023) [36]	Quest – based gamification in software development labs	Structured challenges and motivation
Hainey & Baxter (2024) [42]	Serious RPG for programming education	Immersive and personalized learning
Zhong (2023) [40]	Personalized computerized RPG environment	Engagement, adaptive learning
Arnedo-Moreno & Garca-Solrzano (2025) [44]	Using commercial RPGs to teach coding	Learner engagement and self-efficacy

Table 4 presents a synthesis of studies examining how Role-Playing Games (RPGs) and game-based learning approaches contribute to programming skill development, particularly for novice programmers. The reviewed literature highlights several recurring strategies that support cognitive, social, and motivational aspects of learning. First, integrating programming tasks into gameplay transforms coding activities into interactive challenges, promoting learning-by-doing and conceptual understanding. Second, gamification and motivation mechanisms such as quests, points, and rewards help sustain engagement and perseverance during complex problem-solving processes. Third, collaborative and social learning within RPGs encourages communication and teamwork, reinforcing essential software engineering competencies. Additionally, immersive and adaptive RPG environments improve learner satisfaction by personalizing tasks and feedback to skill levels, while attitudinal and professional skill development strengthens employability and reflective

 ISSN:2302-8149
e-ISSN:2540-9719

practice. As summarized in Table 4, the studies collectively demonstrate that RPG-based frameworks not only enhance technical programming ability but also foster the social and emotional dimensions vital for effective learning and professional growth.

5 Conclusion

This study underscores the potential of Role-Playing Games (RPGs) and gamification strategies to enhance programming skill development and learner engagement. The systematic literature review synthesizes 30 studies and reveals five key insights. First are engagement and motivation that improve significantly when programming challenges are embedded in immersive narratives supported by game mechanics and rewards. Second is skill development benefits from RPG frameworks that integrate coding tasks into contextualized gameplay, fostering collaboration and problem-solving. Third are personalization and adaptivity that enhance learning outcomes through tailored challenges and feedback. Fourth is technological integration, including augmented reality, wearables, and natural language processing, deepening immersion through research remains limited. And the last are educational and social impact that extends beyond technical learning, promoting teamwork, professional behavior, and emotional resilience. The novelty of this study lies in proposing a structured conceptual framework that consolidates HCI principles specifically for RPG design aimed at programming education, an area previously unaddressed in existing SLRs. Nevertheless, this research is constrained by the limited number of reviewed studies (n = 30) and its focus on English-language publications from 2019 – 2025, which may exclude relevant non – indexed works. Future studies should expand database coverage, include diverse learning contexts, and empirically validate the proposed framework through experimental or longitudinal designs. By addressing these directions, subsequent research can further advance interactive, user-centered RPGs that effectively cultivate programming competence.

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