Utilizing Adaptive Gamification in an Intelligent Tutoring System for Software Engineering Education

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Abstract

Gamification is increasingly applied in Software Engineering (SE) education to enhance student motivation and engagement. However, existing approaches often follow a one-size-fits-all strategy, which fails to account for the diverse motivational profiles of students. This can result in limited effectiveness and disengagement. In this paper, we present an adaptive gamification concept for MEITREX, an intelligent tutoring system (ITS) in SE education that tailors gamification to students' HEXAD player types, course progress, and competence level. We conducted a requirements and user analysis to identify motivational challenges and individual preferences in SE education, which guided the design of our concept. We developed and implemented the concept in MEITREX, integrating adaptive gamification elements with student analytics, and evaluated it with twelve students in a demo course. Results show that students perceived the system as adaptive to their learning, with quests and progress indicators improving orientation and motivation. At the same time, the effects on procrastination were moderate, indicating a need for additional time management tools. We present this study as a pilot, and we make the source code and collected data publicly available to facilitate replication and longer-term studies. The findings of our first evaluation in a demo course are relevant for researchers investigating personalized learning, educators aiming to improve SE education, and developers of learning technologies seeking to integrate adaptive gamification.

CCS Concepts

• **Applied computing → Interactive learning environments**; • **Social and professional topics → Software engineering education**; • **Human-centered computing →** *Activity centered design.*

Keywords

Adaptive Gamification, Student Motivation, Player Types, Student Diversity, Learning Management Systems, Personalized Learning

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1 Introduction

Software Engineering (SE) education plays a critical role in preparing future software professionals. Maintaining motivation in SE courses remains a challenge, as students often struggle with complex technologies, heterogeneous prior knowledge, and varying learning preferences [33, 38, 48]. Learning Management Systems (LMSs) are often used in SE education to support online or blended learning modes [51] and offer features for remote access to course materials, submitting exercises and assignments, or taking exams [10]. Intelligent Tutoring Systems (ITSs) can be considered a form of LMSs and offer, for example, students in SE education personalized feedback and hints on programming exercises or task recommendations [13]. However, studies show that these systems fail to achieve lasting engagement due to limited personalization options and insufficient motivation and collaboration features [1, 14, 35].

Gamification describes the use of game design elements in non-game contexts [16] and has been widely adopted to address such motivational challenges. Prior research demonstrates promising effects of gamification on engagement and learning outcomes in higher education [5, 22]. Gamification approaches in the domain of SE education showed similar results [2, 43]. Most gamification initiatives take a *one-size-fits-all* approach, offering the same gamification elements to all students in the belief that everyone will be motivated. However, as reported in literature, students respond differently to the same gamification elements, leading to motivational gains for some while others remain unaffected or even demotivated [6]. Student motivation is not uniform but shaped by individual characteristics, learning contexts, and preferences [8, 18, 23].

A promising approach to addressing this gap is adaptive gamification, which tailors gamification elements to students' individual characteristics. Studies indicate that adaptive gamification can enhance engagement and learning efficiency [21, 24, 27], yet its application in SE education remains underexplored.

The *HEXAD* framework [29, 32] is often employed to adapt gamification, providing a taxonomy for capturing different motivational orientations by categorizing students into player types [32]. The adaptation of gamification for different player types is the most popular approach, focusing entirely on the motivational profiles of students. However, since students in SE education have very heterogeneous prior knowledge and varying learning preferences, adapting gamification solely to the motivation profile of the students may not be sufficient. ITSs are uniquely positioned to extend the personalization of gamification beyond player types. As they continuously monitor the learning progress and competencies of each student, they can adapt the system and its gamification elements to the individual course progress of students, incorporating their current competency level to dynamically refine the adaptation. These dimensions enable a more holistic personalization of gamification, which has not yet been explored in SE education.

In this paper, we present an adaptive gamification concept for *MEITREX* [34], an ITS in SE education that integrates player type, course progress, and competence level into a unified personalization mechanism. Based on a requirements and user analysis with SE students, we designed and implemented an adaptive gamification concept and evaluated its impact on motivation and user experience in an "Software Architecture" demo course. We therefore address the following research questions:

RQ1: *"How can gamification elements be adapted in an ITS for SE education to be personalized for students?"*

RQ2: *"How do students in SE education perceive adaptive gamification in an ITS regarding their motivation and learning experience?"*

Our contributions are threefold: We (1) provide empirically elicited requirements for adaptive gamification in SE education, (2) introduce a novel adaptive gamification concept incorporating student progress and competencies in SE education, and (3) present an evaluation, indicating an improvement in student motivation, and express students' willingness to use the system in other SE courses.

2 Related Work

Gamification in education has been extensively studied in recent years, yielding promising results for enhancing student motivation, engagement, and learning outcomes [9, 17, 52]. In higher education, gamification has been particularly applied in fields perceived as difficult, such as programming, where it can provide structure, incentives, and repeated practice [2, 41]. Huang and Soman [25] propose a 5-step guideline for utilizing gamification. These include understanding the student characteristics, defining learning objectives, structuring experience, identifying resources, and applying gamification elements. Comparably, Kiryakova et al. [26] propose a 4-step guide containing quite similar steps. Compared to Huang and Soman [25], they additionally highlight criteria for well-designed learning activities, including the repeatability of achievements, achievability of achievements, increasing difficulty, and the achievability of objectives via multiple paths.

In SE education, prior studies confirm a growing interest in gamification, but highlight that most initiatives are limited to specific activities, such as programming challenges, project collaboration, or gamified development processes [2, 28, 33, 41]. While these approaches show potential for increasing engagement, they are often developed as proof-of-concept and lack comprehensive integration into broader learning environments, such as ITSs.

A consistent critique across the literature is the prevalence of *one-size-fits-all* gamification, as it overrelies on a narrow set of mechanics, most commonly points, badges, leaderboards, quests, and achievements [17, 28, 37]. These elements are easily transferable from games to education, but do not equally motivate all students. Prior work emphasizes that different students require distinct gamification strategies, as individual preferences and motivational orientations vary significantly [22, 44]. To address this, adaptive and personalized gamification has emerged as a research direction. Early work by Monterrat et al. [36] proposed algorithmic approaches for adapting elements to personality traits, while Böckle et al. [7] developed a design framework outlining criteria such as adaptivity purpose, criteria, and interventions. Studies using the HEXAD player type taxonomy [32] show that tailoring gamification to motivational profiles can increase engagement, but results remain inconsistent and often context-dependent [42, 46]. Importantly, most adaptive approaches still focus primarily on player types, neglecting other dimensions such as individual learning progress or preferences.

Recent research highlights the potential of extending adaptivity to student progress. ITSs, by design, track students' competencies and provide opportunities for fine-grained adaptation [47, 49]. Integrating data about student activities into gamification allows systems to recommend challenges aligned with students' current abilities, reducing both frustration and boredom [24]. Similarly, studies suggest that behavior-based adaptation, using indicators like activity patterns or collaborative engagement, can refine personalization and sustain motivation over time [3, 4, 18]. While these approaches have been studied in adaptive learning systems, they have rarely been systematically combined with gamification, and even less so in the specific context of SE education.

Related work has laid the groundwork by demonstrating the potential of gamification in SE education and by exploring personalization primarily through player types. However, existing approaches remain limited, as they focus narrowly on motivational profiles while neglecting cognitive and progress-related factors, and lack empirical grounding in student needs and preferences. In contrast, our work introduces an adaptive gamification approach that combines player type, course progress, and competence level into a unified personalization mechanism. This multi-dimensional adaptivity, grounded in a requirements and user analysis with SE students, represents a novel step toward designing gamified ITSs.

3 Requirements and User Analysis

To design an adaptive gamification concept, we conducted a Requirements Engineering (RE) process combined with a user analysis of SE students. The goal was to identify motivational challenges, gather preferences for gamification elements, and derive requirements for adaptivity. Section 3.1 describes the applied RE process, while Section 3.2 presents the results and the requirements that were considered in the concept design.

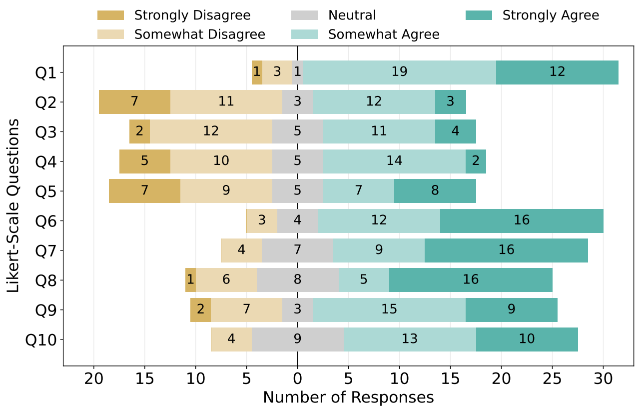


Figure 1: Motivation factors of students in SE education.

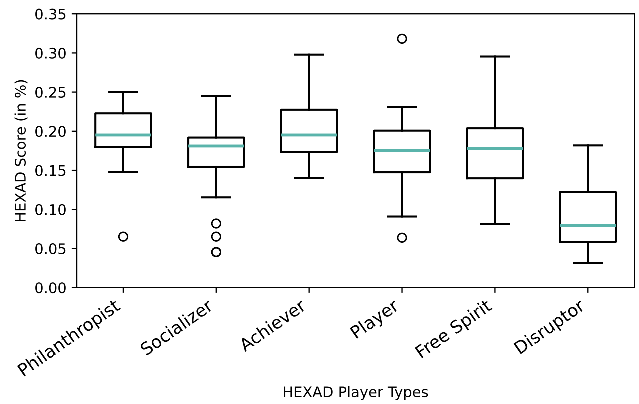


Figure 2: User analysis using the HEXAD player types [29].

3.1 Requirements Engineering Process

The RE process was designed to capture student-centered requirements for an adaptive gamified ITS. Building on established definitions from Pohl and Rupp [40], we structured the process into elicitation, analysis, specification, and prioritization. The primary focus was on students in SE education, as their motivational challenges and learning preferences shape the effectiveness of gamification.

To elicit requirements, we conducted an online questionnaire targeting university students in Germany and the United States. The questionnaire consisted of five sections: (1) demographics, such as age, gender, and study background, (2) motivation, including self-assessment of learning struggles and preferences, (3) experiences with existing gamified apps (frequency, perceived benefits, frustrations) (4) application design, including opinions on gamification and interaction styles, and (5) HEXAD questionnaire using the 12-item short version by Krath et al. [29] to classify player types.

The questionnaire was distributed online to SE students in Germany and the United States via institutional mailing lists and student social media channels. A prerequisite for participation was that students were enrolled in a computer science or related program and had completed at least one SE course. The data provided both quantitative measures (using Likert scales and rankings) and qualitative insights (from open-ended questions). This combination enabled us to identify recurring motivational struggles, common expectations, and potential pitfalls associated with gamification in educational systems. Based on the findings, requirements were specified and prioritized using the *MoSCoW* method [11].

3.2 Results and Gathered Requirements

A total of 45 students participated in the questionnaire, of which 36 provided complete responses that were included in the analysis. The students were mainly enrolled in SE and related study programs in Germany (32 students) and in the United States (4 students). The average age was 23 *(min. 19, max. 32)*. Further demographic details, such as gender or semester of study, were collected but are not relevant to the following analysis. All questionnaire questions and collected data can be accessed on Zenodo[1].

The results reveal that many students face recurring motivational challenges. Figure 1 illustrates these challenges. The respective Likert-scale questions are: **(Q1)** I sometimes struggle to stay motivated when studying, **(Q2)** I often feel lost, not knowing which topics/exercises I need to focus on, **(Q3)** When I fall behind in a lecture, I find it difficult to catch back up, **(Q4)** I sometimes find course tasks too challenging, which affects my motivation, **(Q5)** I feel confident in my time management skills/having a consistent learning schedule, **(Q6)** Clear and structured learning goals help me learn more effectively, **(Q7)** I prefer deciding for myself what to work on next, **(Q8)** I prefer learning at my own pace rather than following a fixed schedule, **(Q9)** If I'm unsure what to do next, I will just procrastinate, and **(Q10)** I need pressure from a deadline to be able to work effectively. In particular, 86% of the respondents agreed (for this section, we combine *agree* and *strongly agree*) that they sometimes struggle to stay motivated when studying, while only 7% explicitly disagreed. A proportion of 64% of the students stated that they tend to procrastinate when unsure about what to do next, highlighting the importance of clear guidance in learning environments. Similarly, 36% reported difficulties catching up once they had fallen behind, and 17% agreed that tasks sometimes felt too challenging, which negatively impacted their motivation.

Structured and transparent learning support is strongly valued. 80% of the students agreed that clear and structured learning goals help them learn more effectively, and 40% expressed confidence in their time management skills, although 35% also disagreed. The majority of students emphasized autonomy, with 70% preferring to decide for themselves what to work on next and 64% favoring learning at their own pace rather than following a fixed schedule.

When asked about their experience with gamification in non-educational contexts, most students were familiar with gamified applications such as fitness trackers or language learning platforms (e.g., *Duolingo*[2]). They associated gamification with enjoyment, increased engagement, and better progress tracking. However, they also expressed concerns about superficial implementations, irrelevant rewards, and overly competitive features. These findings underline that gamification in education must be meaningful, adaptive, and closely aligned with learning goals to avoid distraction.

[1]https://doi.org/10.5281/zenodo.17230020

[2]https://en.duolingo.com/

The HEXAD analysis shows that the most common player types among the participants are the *Philanthropist* and the *Achiever*. The user analysis in the RE process is illustrated in Figure 2. *Free Spirits*, *Socializers*, and *Player* appear slightly less frequently. The least common type is the *Disruptor*. This distribution suggests that altruistic, mastery-driven, and autonomy-oriented elements are particularly important for SE students, whereas purely competitive mechanics resonate less strongly. Nevertheless, the existence of all six types suggests that gamification elements that are considered not beneficial for a player type could potentially be viewed as demotivating in a *one-size-fits-all* gamification strategy.

Based on these findings, several requirements for adaptive gamification were derived and prioritized. **(Req1)** First, the system must include clear progression indicators and structured learning goals, since lack of orientation is a key driver of procrastination and demotivation. **(Req2)** Second, gamification must adapt to different motivational profiles to account for the diversity of student motivation, ensuring that altruistic, mastery-focused, and autonomy-driven students are supported without alienating minority groups. **(Req3)** Third, the system must balance autonomy and guidance. Students should have freedom to choose tasks and pace, but deadlines and milestone-based feedback are needed to maintain consistent engagement. **(Req4)** Finally, gamification elements must remain meaningful and aligned with learning objectives, avoiding superficial rewards or purely competitive mechanics that risk discouraging parts of the student population.

4 Adaptive Gamification Concept

Based on the requirements, three adaptation factors emerged, which serve as the basis to adapt gamification elements: (1) *Player Type*, which accounts for motivational diversity, (2) *Course Progress*, which aligns gamification with the student's advancement through the curriculum, and (3) *Competence Level*, which ensures that challenges and rewards match individual skills. To overcome the limitations of static, *one-size-fits-all* gamification, we introduce gamification adaptation in MEITREX [34] that accounts for the diversity of SE students. The reason for using MEITREX is that it already enables us to analyze the individual competency levels according to the CS2023[3] computer science competency standard, and to track students' individual course progress. In the ITS, this CS2023 competency standard was implemented using the competencies in JSON format by Anzinger et al.[4]. However, the adaptive gamification concept in this paper is applicable to any learning platform and should serve as proof of concept in MEITREX.

To operationalize the gathered requirements, the concept is structured around several components. First, Section 4.1 provides an illustrative running example that demonstrates how adaptive gamification unfolds for different personas. Second, the choice of gamification elements is explained in Section 4.2. Finally, the adaptation mechanism dynamically aligns the elements with the student's profile and current state, as explained in Section 4.3. The implementation of the adaptive gamification concept in MEITREX is open-source and publicly available on GitHub[5].

[3]https://csed.acm.org/
[4]https://doi.org/10.5281/zenodo.14045625
[5]https://github.com/MEITREX/gamification_service

4.1 Illustrative Student Scenario

To illustrate how the adaptive gamification concept unfolds in practice, we present two personas: *Anna*, an Achiever, and *Peter*, a Philanthropist. Both are enrolled in the same SE course but differ in their motivational profiles, course progress, and competence levels.
Anna – The Achiever: Anna is in her third semester of a Bachelor's program. She has strong prior knowledge in programming and typically performs above average in assignments. According to the HEXAD assessment, she is an Achiever who is motivated by mastering challenges and demonstrating competence. At the beginning of the course, Anna is presented with quests that align with her competence level. Tasks that are too easy are de-emphasized, while more advanced optional quests are highlighted to maintain her engagement. Her experience points (XP) and level system show rapid progression, with milestone achievements unlocked for completing complex tasks ahead of schedule. Achievements emphasize mastery, such as "*Completed advanced coding challenge without hints.*" Since autonomy is less central to her profile, customization options are available but not emphasized in her dashboard. The adaptivity ensures that Anna remains consistently challenged and motivated, thereby avoiding disengagement from trivial tasks.
Peter – The Philanthropist: Peter is in his first semester of a Master's program and has limited prior knowledge in designing software architectures. He scored highest on the Philanthropist profile, indicating that he is strongly motivated by helping others and contributing to his community. His course dashboard emphasizes social features. Cooperative quests are recommended, such as peer-reviewing assignments or mentoring less experienced classmates. His XP progression is framed around personal accomplishments and community contributions, with achievements like "*Supported three peers with feedback.*" Because his competence level in software architecture is limited so far, the system assigns him quests of moderate difficulty, ensuring that he does not feel overwhelmed. Achievements celebrate his collaborative spirit rather than individual performance, while customization features are highlighted to provide autonomy in shaping his learning experience.
Comparison: Although both Anna and Peter interact with the same pool of gamification elements, the system emphasizes and adapts them differently based on the students. Anna receives more challenging quests and mastery-oriented achievements, whereas Peter is encouraged to participate in collaborative activities and rewarded for community engagement. Course progress also plays a role as both advance through the course, the nature of available quests and achievements evolves, ensuring that the system remains meaningful and aligned with their respective competence levels.

4.2 Gamification Elements

Previous research shows that the motivational effects of gamification depend heavily on the selected elements and their alignment with student needs [17, 22]. Therefore, our design avoids an arbitrary collection of features and instead focuses on a targeted set of elements that address the motivational challenges reported by SE students and also align with the gathered requirements. While the gamification elements can be mapped directly to HEXAD player types, research has shown that an indirect mapping through gamification element categories is more effective.

Table 1: Choice of adaptive gamification elements based on the gameful design by Tondello et al. [45]

Category	Gamification Elements
Socialization	Q&A Forum; Leaderboards
Assistance	Q&A Forum; AI Tutor Character; Motivational Quests for weaker areas
Immersion	AI Tutor Character
Risk/Reward	Item Lottery
Customization	Profile Decorations; Points Shop; Items
Progression	XP System & Levels; Achievements; Progress Bars & Performance Statistics
Altruism	Answer questions in Q&A Forum
Incentive	Achievements; Quests; Collectible Items

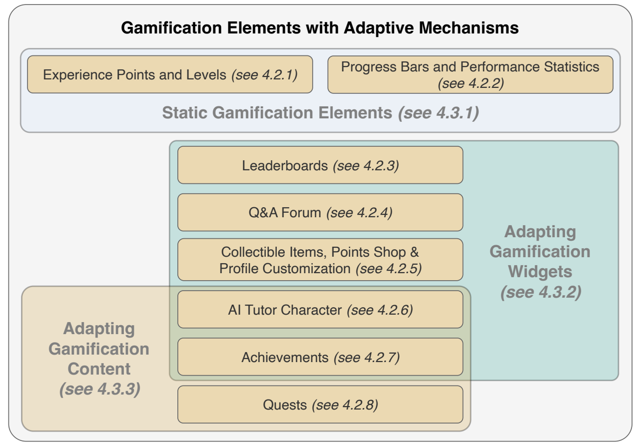


Figure 3: Overview of the gamification design.

Tondello et al. [45] identified eight gamification element categories through principal component analysis: *Socialization*, *Assistance*, *Immersion*, *Risk/Reward*, *Customization*, *Progression*, *Altruism*, and *Incentive*. Each category groups similar elements that appeal to overlapping motivational preferences. By classifying our elements into these categories, the system can recommend elements based on student behavior, even beyond the player's primary type. This indirection enhances flexibility, as it allows the adaptation engine to suggest new gamification elements that share a conceptual basis with those already enjoyed by the student. Table 1 summarizes these categories along with our designed gamification elements. The table illustrates the distribution of diverse elements across categories, providing a basis for adaptive recommendations that extend beyond a direct mapping of player types to individual elements. Additionally, Figure 3 provides an overview of the gamification elements according to adaptation mechanisms, highlighting the dimensions of adapting gamification widgets and gamification content to individual students.

Although many of the proposed gamification elements themselves are not new and have been applied in other learning environments, the integration and interaction within an ITS for SE education and their adaptation to individual students are novel.

4.2.1 Experience Points and Levels. An experience points (XP) system with levels forms the foundation of our progression design. XP systems are a well-established mechanic in games, where students collect XP through actions and advance to higher levels once thresholds are reached. In our concept, the XP system provides a global measure of effort invested in studying across different courses and semesters, thereby creating a single, intuitive indicator of overall progress (Req1). However, since we consider XP to be a global indicator, this does not reflect how much a student has learned. XP is awarded for a broad range of learning activities, reflecting both individual study and community participation. For example, watching a lecture video grants XP proportional to its duration, reading a lecture document is rewarded based on page count, and completing a quiz set yields XP according to the number of items solved. Larger milestones, such as completing a programming assignment, grant substantial XP bonuses. Contributions to the learning community, such as posting in the forum or having an answer accepted, are also rewarded. This mapping of actions to XP ensures that all types of engagement are recognized and rewarded.
When a student gathers enough XP, their level increases. A critical design consideration was determining the XP thresholds for leveling. We adopted a logarithmic progression model for leveling, ensuring fast XP gains at lower and slower gains at higher levels.

4.2.2 Progress Bars and Performance Statistics. Progress indicators are among the most established gamification elements in educational systems, as they provide both motivational incentives and essential feedback about learning progress. Beyond satisfying students driven by progression, they serve all students by visualizing advancement within the course curriculum and clarifying the distance to upcoming goals. This aligns directly with the requirement to counteract procrastination and disorientation (Req1). As we integrate the gamification concept into an existing ITS that analyzes individual competency levels according to the CS2023,4[3] competency standard in CS education, we can directly retrieve and display the data as progress bars. Thus, performance statistics do not merely show how much course material has been completed, but also how well students have mastered specific desired competencies.

4.2.3 Leaderboards. Leaderboards allow students to compare their performance with that of their peers, and recent research has shown that they can influence learning outcomes in a manner similar to explicit goal-setting [30]. Prior research also highlights challenges in their design. A static, *one-size-fits-all* leaderboard tends to disproportionately favor students who have participated the longest, making it difficult for newcomers to catch up [39]. To mitigate these issues, different strategies have been proposed. Park and Kim [39] distinguish between macro-leaderboards, which track overall scores, and micro-leaderboards, which focus on specific activities. This enables high performers to be recognized globally, while others can excel in narrower domains. Given the context of SE courses with relatively small participant numbers, we adopt a seasonal leaderboard design, allowing students to compare in an *All-Time Leaderboard*, *Monthly Leaderboard*, and *Weekly Leaderboard*, using comparable points earned by completing course material. Figure 4a illustrates the seasonal leaderboard with profile customizations.

4.2.4 Q&A Forum. Asynchronous and synchronous communication tools play a central role in supporting collaboration and knowledge exchange in online learning environments. To this end, our concept integrates a Q&A forum which addresses the need for socialization and assistance while also fostering altruistic contributions (Req2). Threads can be created either as *information posts* or as *questions*, with the latter designed to solicit peer support. To enhance contextual relevance, threads can be linked to specific timestamps in lecture videos or to particular pages in documents, making them visible to other students directly at the point of need. Other students can reply, and responses are subject to up- and down-voting, thereby highlighting helpful contributions. Each student's cumulative "vote points" are displayed, signaling expertise to peers and simultaneously incentivizing knowledge sharing. Beyond serving as a support mechanism for struggling students, this feature also enables "learning by teaching", where answering questions reinforces the student's own understanding [12, 19]. Figure 4b shows a thread in the Q&A forum, with up- and down-voted answers and an approved answer by the author of the thread.

4.2.5 Collectible Items, Points Shop & Profile Customization. Collectible items provide students with a layer of personal expression and extrinsic reward. However, as highlighted in the requirements analysis, such items must be meaningful to sustain engagement. Therefore, collectible items in our concept are tied to profile customization, allowing students to personalize their learning environment and express individuality. Figure 4c presents the item shop, featuring collectible items of varying rarities, as described below.

Collectible Items: Students can obtain items through various means, such as completing quests, achievements, or assessments. Examples include unique profile pictures, decorative frames, background colors or patterns, and alternative tutor mascots. Items are classified by rarity *(Common, Uncommon, Rare, Ultra-Rare)*, with higher rarity indicating greater difficulty of acquisition.

Currency and Item Shop: To regulate acquisition, students earn a virtual currency (coins) from daily quests, achievements, and course activities. Coins can be spent in the points shop to purchase items directly. Prices scale with item rarity, ensuring that rare items require consistent effort over time.

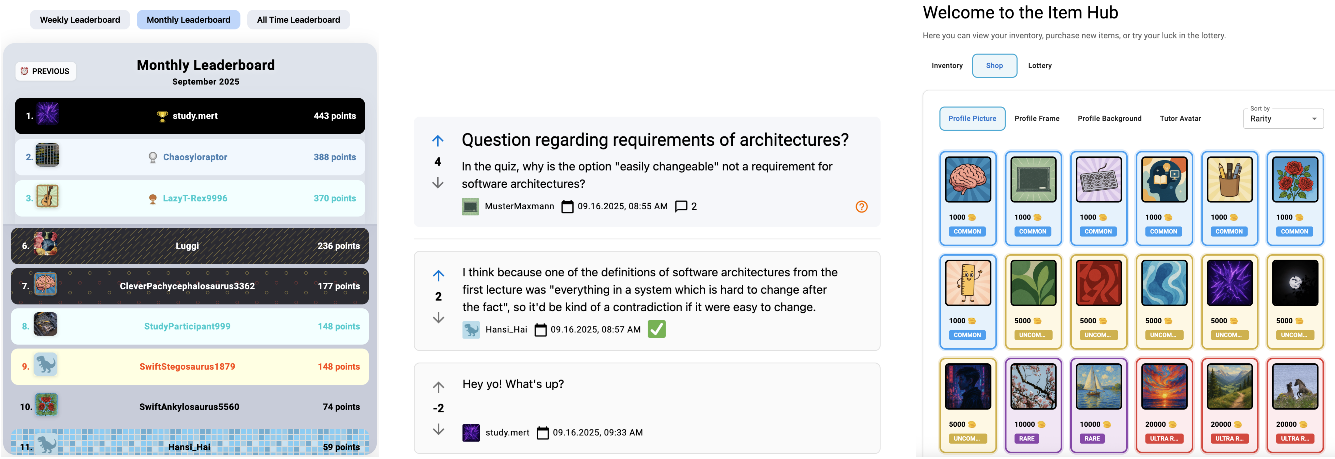
Item Lottery: For students motivated by *Risk/Reward* mechanics, the system also offers a lottery option. Here, coins can be wagered for a chance to obtain rare items otherwise unavailable in the shop. Lottery odds are carefully balanced (e.g., 65% common, 20% uncommon, 12% rare, 3% ultra-rare) to maintain fairness and prevent devaluation of rare items.

Customization: Collected items can be equipped via the student's inventory, which provides slots for each item type (e.g., profile picture, frame, background). These customizations are visible in public areas such as the Q&A forum and leaderboards, allowing students to showcase their achievements and identity. This not only strengthens individual ownership but also fosters recognition among peers, linking cosmetic personalization with social visibility.

4.2.6 AI Tutor Character. While traditional gamification focuses on structural mechanics, the AI tutor character provides a narrative and immersive dimension that combines support, personalization, and motivation. The tutor is powered by a Large Language Model (LLM) extended with a Retrieval-Augmented Generation (RAG) pipeline [31], which enables it to access lecture materials uploaded to the system. The technical realization of the AI tutor character is not relevant for the rest of this paper. Being aware of the course content allows the tutor to answer questions precisely and to link responses to relevant content. Students can interact with the tutor in a chatbot format, ask follow-up questions, or request clarification, enabling an interactive learning experience. Such conversational agents have already been shown to positively impact study performance and perception [50]. The tutor also delivers motivational messages to continue learning when entering MEITREX. This personification leverages the emotional response in people [15], which, in our context, can be used in order to motivate students to complete tasks. During exercises, it can provide hints or direct support when a student struggles with a task. Within the dashboard (see Figure 5), it appears as a companion that responds to student questions. The AI tutor provides structured assistance and orientation (Req1), adapts to motivational diversity through personalized interactions (Req2), and balances autonomy and guidance by leaving initiative to the student while offering help when needed (Req3).

4.2.7 Achievements. Achievements are among the most widely used gamification elements, serving as symbolic recognition of milestones reached by students. In our concept, achievements go beyond static, predefined goals by combining shared milestones that are identical for all students with adaptive milestones generated dynamically for individual students to sustain motivation. A key design consideration is the balance between meaningfulness and motivation (Req4). While achievements should encourage repeated engagement, research also indicates that more difficult achievements improve student performance and has partially indicated that a lower quantity of achievements leads to improved motivation compared to higher quantities of achievements [20]. To address this, we distinguish between non-countable achievements, which reflect substantial mastery (e.g., completing all assignments of a module), and countable achievements, which allow incremental extension. By limiting adaptive generation to countable achievements, the system ensures that non-trivial, long-term goals remain stable markers of progress. Figure 5 displays an achievement widget, indicating the student's status for reaching an individual achievement.

4.2.8 Quests. Quests are a core mechanic in our gamification concept, designed to structure learning activities as goal-oriented tasks that provide both orientation and motivation (Req1, Req4). In our system, every learning task, such as watching a video, solving a quiz, or completing a programming assignment, can be embedded into a quest. Some quests represent short-term tasks (e.g., completing a single quiz), while others involve long-term challenges (e.g., submitting an assignment or participating in group work). Therefore, we ensure daily and weekly quests. Figure 5 shows an example of individual daily quests. In summary, quests serve as the narrative and structural backbone of our adaptive gamification. They transform abstract course tasks into tangible learning goals, provide regular incentives for engagement. Together with XP and achievements, quests complete the progression loop by linking immediate actions, intermediate goals, and long-term milestones.



(a) Leaderboard with customizations. **(b) Forum thread with message up- and downvotes.** **(c) Item shop for profile pictures.**

Figure 4: Gamification Element Design.

4.3 Adaptation Mechanism

We build on Böckle et al.'s [7] framework to determine where adaptation should occur and on Knutas et al.'s [27] idea of personalized task generation to determine what to adapt in day-to-day learning activities. Concretely, our mechanism combines: (i) an initial player-type–based recommendation score over gamification element categories (after Tondello et al. [45]) with (ii) continuous, data-driven refinement from in-system behavior like course progress, student competencies, and user feedback. This two-stage engine powers two layers of adaptivity: (a) adaptive widgets (which elements are surfaced on the dashboard) and (b) adaptive content (what each element contains for each individual student). The underlying design decisions, score computation, refinement algorithm, and widget/-content adaptations are described in this section.

4.3.1 Static Gamification Elements. In our design, the XP system and levels, as well as progress bars and performance statistics, are deliberately kept static. They are always present, identical in function for every student, and never down- or up-weighted by the adaptation engine. We made this choice for two reasons. First, these elements provide the primary orientation of the system as XP establishes a stable, global measure of study effort and milestones, while progress bars expose curriculum coverage and competence development. Hiding or reshuffling these signals would undermine transparency and make it more difficult for students to assess their progress and determine next steps. Second, fixing these elements reduces cognitive load and preserves trust. The indicators look and behave the same across sessions, which helps students form accurate mental models of how the ITS tracks effort and progress.

4.3.2 Adapting Gamification Widgets. At the widget layer, the system decides which elements to surface prominently on the dashboard for a given student. Concretely, the widget selector can promote, de-emphasize, or rotate five widget families. (1) Leaderboards, (2) Q&A Forum, (3) Collectible Items / Points Shop / Profile Customization, (4) AI Tutor Character, and (5) Achievements. The goal is to match "what you see first" to stable preferences and current needs, while keeping navigation to all features consistently available. To decide which widgets to surface, the system first forms an initial preference profile and then refines it over time from lightweight signals. The dashboard (see Figure 5) exposes two fixed widget slots that the widget selector fills and refreshes by default every twelve hours (students may opt for six hours or 24 hours) to rotate highlighted widgets. Access to all features (e.g., the Q&A forum) via the standard navigation menus remains unchanged.

Preference Seeding: For an initial estimate of the student's HEXAD player type upon their first login to the system, we use a HEXAD questionnaire by Altmeyer et al. [3] which consists of either-or questions. The questionnaire then calculates the individual weight for each player type (students can have more than one strong player type). Students can skip the steps, but if they do, we start with a neutral baseline (equal weights across all six player types).

Initial Estimation of Recommendation Score: Starting from the HEXAD questionnaire, we compute a category-level *recommendation score* that expresses, for each of the eight element categories (see Table 1), how often it should appear on the course page *relative to the others*. Rather than mapping player types directly to concrete gamification elements, we first map the normalized HEXAD vector (the player type questionnaire results for all player types as a vector) to category preferences using the correlation structure reported by Tondello et al. [45]. The idea is that affinity to a category predicts affinity to all elements inside it (e.g., students who enjoy Achievements often also enjoy Collectibles in the same category). Concretely, we multiply the six-dimensional, min–max normalized HEXAD vector by a 6×8 correlation matrix to obtain raw category scores. A linear transformation then shifts these raw values into $[0, 1]$, followed by a normalization step that turns them into a distribution summing to 1. This distribution is interpreted as a *relative frequency* signal for the widget selector (i.e., it does not change the total number of widgets displayed, only their mix). In practice, a purely linear mapping compresses many students close together into the mid-range because, as the correlation coefficients determined in [45] are at most slightly negative.

To distinguish between recommendations, we apply a simple "polynomial mapping". This spreads mid-range values (making genuine preferences more visible), while not entirely removing the impact of negative correlations. Finally, these category weights are used as inputs to the widget selector. Concrete widgets inherit their category via a binary mapping (an element either belongs to a category or not), providing a transparent bridge from player-type input to category preference and, ultimately, to the actual gamification widgets that appear in the dashboard.

Refining the Recommendation Score: After seeding the category preferences, the system periodically refines the recommendation score by default every twelve hours using user-facing feedback and rotation rules. When a gamification widget is shown, a banner may ask for feedback with three options: (1) Show more often, (2) Just right, or (3) Show less often. Each response applies a small, fixed adjustment rate of (±0.05) to the corresponding category weight, after which the vector is re-normalized. If a student selects *Show more often* or *Show less often*, we temporarily increase the feedback-request frequency by 1.5× (i.e., we ask more frequently). Selecting *Just right* reduces the frequency by the same factor (i.e., we ask less frequently). The frequency is bounded between one request every eight days (upper frequency limit) and one request every 30 days (lower frequency limit), ensuring periodic re-evaluation without spamming. When using the refined scores to generate the next recommendation, the widget selector first applies a minimum threshold so that each category retains a probability of at least 5%. The remaining (uncapped) categories retain their relative proportions after normalization. This ensures that the system can continue to recommend categories of gamification elements that the student has not previously shown interest in. The reason for this is to give students the opportunity to change their minds.

4.3.3 Adapting Gamification Content. Beyond deciding *which* gamification elements are featured on the dashboard, the system adapts *what* those elements contain. Content adaptation is built on a *goals* framework. Goals are a generalization of the tasks or conditions that a student must fulfill to achieve an accomplishment or complete a mission, such as quests and achievements, which both require specific goals. The goal system is designed to enable the dynamic, rule-based generation of tasks and the generation of composite tasks that comprise multiple smaller tasks. The goal system also provides functions for tracking students' progress toward these goals. Both achievements and quests are instantiated through this framework, enabling on-demand, data-driven generation that responds to learner state and preferences.

Quests: To realize adaptive quests, we defined them as *small, time-bounded tasks* intended to be completed in about an hour and are rewarded with coins (currency). The system generates three daily quests at midnight, with selection adapted to the student's recommendation score (from Section 4.3.2) and course progress. Quests are drawn from four types. *Learning* (consume specific lecture material), *Exercise Progress* (work on due or suggested assessments), *Competency Level* (target topics where competence is low), and *Specialty* (align with preferred gamification categories, e.g., answer a forum question or equip an item). If a chosen type cannot yield a meaningful task (e.g., all lectures already completed), fewer than three quests may be issued to avoid contrived tasks.

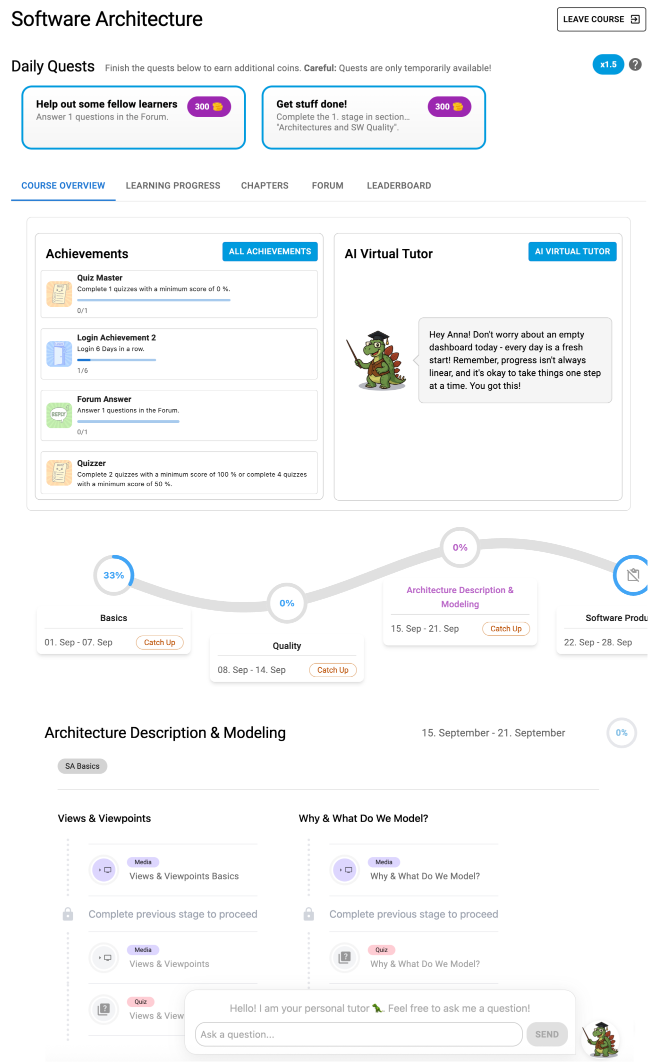


Figure 5: Course dashboard with gamification widgets.

To promote regular engagement, the system supports *quest streaks* that increase rewards for consecutive days with all quests completed. The generation logic follows *decision trees* rule-based selection tied to prerequisites, suggested dates, and learning intervals.

Achievements: In the concept, achievements are a mixture of *predefined, course-wide milestones* (identical for all learners) and *user-specific, dynamically generated milestones* that extend engagement over time. A known challenge with dynamically created achievements is that they can conflict with the usual expectation that achievements represent milestones and *collecting all achievements* is perceived as mastering the game. Continuously adding new achievements can undermine that sense of closure, especially when some students have other publicly visible achievements than others. Therefore, we restrict the dynamic creation to *countable achievements*, i.e., goals that depend on repeating the same action (e.g., "complete 10 quizzes"). When a learner completes one tier, the system proposes the next step (e.g., "20 quizzes").

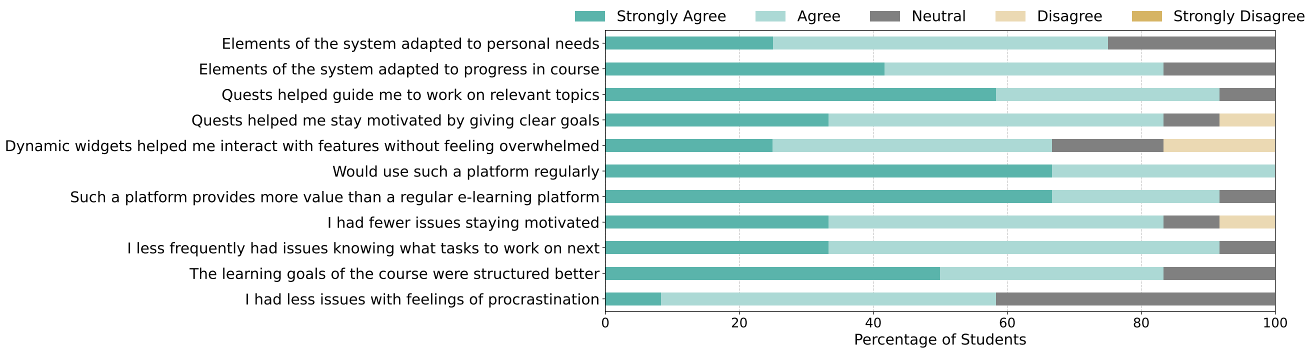


Figure 6: Perceived students' learning experience in post-experiment questionnaire.

Although unlimited adaptive achievement tiers can, in principle, create moving targets, we prefer this over frustrating learners who see others receive achievements they can never obtain. Achievements are also based on the previously mentioned *goals* framework, which provides the technical backbone. Each achievement is defined by a template (e.g., count target), preconditions (prerequisites, suggested dates), and success conditions.

AI Tutor Character: The AI tutor operates as a conversational agent (LLM with retrieval over uploaded course materials) that provides individually framed, *context-aware answers* and *exercise-level hints* in free-form dialogue. To add a narrative, immersive layer, the tutor appears as a mascot-like character that can *pop up on the dashboard* (see Figure 5) with short personalized motivational messages tailored to recent activity (e.g., acknowledging a strong programming performance or encouraging a retry after failure). The content of the tutor's messages is based on the learner's progress to date and, if necessary, directs them to the next relevant activity, thereby supplementing quests and achievements.

5 Evaluation

This chapter outlines the evaluation of our adaptive gamification approach in MEITREX. The following sections describe the evaluation design (Section 5.1), present the results (Section 5.2), and discuss their implications for SE education (Section 5.3).

5.1 Evaluation Process

To evaluate the impact of adaptive gamification in SE education, we conducted a user study with twelve students enrolled in SE-related degree programs. Participants were recruited at the University of Stuttgart, Germany. We created a dedicated demo course, "Software Architecture", within MEITREX that included lecture slides, pre-recorded videos, and assessment tasks to simulate an authentic yet controlled learning environment used exclusively for the evaluation. Each participant interacted with the system over the course of one week, participating in three separate sessions of approximately 60 minutes each. Sessions were conducted remotely using a think-aloud protocol with screen sharing. After a brief introduction in the first session, participants worked independently, explored the course materials, and interacted with both static and adaptive features (e.g., AI tutor, quests, achievements), followed by short debriefs at the end of each session.

This multi-day setup was chosen to observe features that adapt across days (e.g., daily quests, rotating widgets, feedback-driven adjustments) rather than in a single session. Instrumentation consisted of a pre-exposure questionnaire (demographics, prior experience with gamified applications, and familiarity with software architecture) and a post-exposure questionnaire that captured both quantitative indicators and qualitative reflections. The post-study questionnaire combined Likert-scale items (e.g., perceived usefulness and clarity of guidance, perceived motivational support) with open-ended questions (e.g., most/least helpful features, suggestions for improvement). All items were aligned with our research questions. Analysis followed established practices in SE education. Closed-ended items were summarized using descriptive statistics to reveal central tendencies, while open responses and notes from the think-aloud sessions were thematically analyzed to identify recurring patterns related to usability, guidance, and motivation. All questionnaires and collected data can be accessed on Zenodo[1].

5.2 Results

Twelve SE students completed the user study. Prior exposure to gamified applications was common (41.7% reported (semi-) regular use, 33.4% regular use, 25.0% no experience). Figure 6 presents the results of the Likert-scale closed questions. Overall, 75% agreed (for this section, we combine agree and strongly agree) that gamification elements adapted well to their *personal needs* (25% neutral), and 83% agreed that they adapted well to their *progress in the course* (17% neutral). The adaptive *quests* were especially well received as targeted guidance. 92% agreed that quests helped them work on relevant topics, and 83% agreed that quests helped them to stay motivated by providing clear daily goals. Dynamic widgets that rotate the course dashboard were also accepted by most participants (67% agree; 17% neutral; 17% disagree). Overall acceptance and comparative judgments were high as all students indicated that they would use such a system regularly if it were part of a real course setting, and 92% agreed that the system provides more value than established e-learning platforms.

Qualitative analysis of open comments and think-aloud notes revealed three recurring themes. First, *structure and orientation*, as students praised that quests and progress indicators "make it obvious what to do next", reflecting the intent of providing clear progression and next-step guidance.

Second, *motivational diversity* as some participants emphasized leaderboards and competitive elements, while others preferred quests, customization/collectibles, or the Q&A forum.
Third, *the role of the AI Tutor character*. Participants overall valued quick clarifications but criticized occasional limitations in taking too long. Notably, the personified, mascot-like presentation was viewed positively, with requests for richer, more interactive behavior.

Students also provided concrete improvement suggestions. Several asked for *clearer explanations* of gamification mechanics- For *quests*, participants recommended a finer control and variety, including an option to skip/swap a daily quest, and more explicit links from quests to the relevant page or activity. Regarding *gamification widgets*, students wanted the dashboard to emphasize essentials first (i.e., display individual progress up front) and requested the ability to pin widgets or reduce widget rotation when they appreciate them. Social and collaboration features were also requested, including *messaging* and a *study group finder*, complementing the Q&A forum. Additional requests included a *dark mode* and more *profile customization* options (including custom AI tutor avatars).

5.3 Discussion

The results provide actionable answers to *RQ1* by clarifying *which* gamification elements in an ITS for SE education can be adapted and *how* to do so without hiding essential information from other students. A layered strategy emerged: (i) keep *static, universally useful* orientation signals (XP/levels, progress and competence indicators) visible for all students, (ii) adapt the *widget layer* to personalize what is surfaced on the individual dashboard and (iii) adapt *content* within gamification elements that benefit from learning goals, i.e., with short-term quests, long-term achievements, and tutor support.

In relation to *RQ2*, students overall perceived adaptive gamification positively for motivation and learning experience. Large majorities agreed that elements were adapted to their personal needs and course progress. Quests and progress indicators were repeatedly cited as making the next steps clear, and acceptance was high (students would use the system in a real course setting and judged it more valuable than established LMSs). At the same time, views on the AI tutor and on rotating widgets were more mixed, indicating a need for clearer introductions and explanations of gamification mechanics and controllable surfacing (e.g., pinning, gentler rotation). Procrastination feedback was less consistent, suggesting that guidance could be complemented with more time-management features (e.g., deadline reminders). Overall, the study suggests that layered personalization enhances orientation and motivation in SE courses, also highlighting concrete possible future improvements to broaden its impact and durability.

6 Threats to Validity

Internal validity: A potential threat arises from the artificial nature of the demo course. The students were aware that the course was created exclusively for evaluation purposes. Their engagement and interaction with MEITREX may therefore differ from behavior in a real course with grading and long-term stakes. To mitigate this, we utilized real course content and distributed participation across three sessions within a one-week period to simulate repeated usage and reduce the novelty effect.

External validity: The study was conducted with a small group of twelve SE students from one university. This limits the generalizability of the findings to other institutions, disciplines, or larger and more diverse cohorts. Moreover, the implementation in MEITREX is a proof of concept, and results may not directly transfer to established LMSs. Still, the conceptual design of adaptive gamification is independent of the specific software, which facilitates replication in different educational contexts.
Construct validity: The evaluation relied on self-reported measures of motivation and learning experience, which can differ from actual behavior and learning outcomes. Students may state that the system increased their motivation, while their actual study time remained unchanged. The presence of novelty effects may also have influenced responses, since students interacted with an adaptive system for the first time. To mitigate this, we included both Likert scales and open-ended questions in the questionnaire to express their perception of the system.
Conclusion validity: The relatively short evaluation period and the limited number of participants constrain the strength of the conclusions that can be drawn. Students engaged with the demo course for one week, which is sufficient to assess usability and first impressions, but not to evaluate long-term learning effects or sustained motivation. Therefore, our findings should be interpreted as exploratory evidence of feasibility and student perceptions rather than as definitive proof of effectiveness.

7 Conclusion and Future Work

This paper introduced an adaptive gamification approach for an intelligent learning environment in SE education. We keep static orientation signals (progress/competence indicators, XP/levels) visible to all students in the same way, adapt the gamification widget layer to personalize which gamification elements are presented to the individual students on the course dashboard (e.g., leaderboards, Q&A forum, achievements), and adapt gamification content in quests, achievements, and the AI tutor based on students' individual player type, course progress, and competence level. A HEXAD-seeded preference profile mapped to gamification element categories and a refinement loop guides the gamification adaptations.

In a one-week study with twelve students from SE-related study programs, we simulated a "Software Architecture" course. Participants perceived the system as adaptive to personal needs and course progress, and consistently valued daily quests and progress indicators for clarifying next steps. Overall acceptance was high as students indicated they would use the system in other SE courses and rated it more valuable than established LMSs. Responses to the AI tutor character were mixed, and the reduction in procrastination was less pronounced, leaving room for improvement, such as gamification elements for time management and guidance functionality.

Future work will involve larger and more diverse cohorts, as well as the long-term use of the system in real courses to evaluate learning outcomes, long-term motivation, and sustained engagement, based on data about student interactions. We also plan to address the improvement suggestions from the evaluation in this study and refine the adaptation mechanisms and rotation to reduce fatigue. Additionally, we will introduce skip/swap and streak options for quests, and enhance controls and analytics for lecturers.

References

[1] Ahmed Al-Hunaiyyan, Salah Al-Sharhan, and Rana AlHajri. 2020. Prospects and challenges of learning management systems in higher education. *International Journal of Advanced Computer Science and Applications* 11, 12 (2020).

[2] Manal M. Alhammad and Ana M. Moreno. 2018. Gamification in software engineering education: A systematic mapping. *Journal of Systems and Software* 141 (2018), 131–150. doi:10.1016/j.jss.2018.03.065

[3] Maximilian Altmeyer, Gustavo F. Tondello, Antonio Krüger, and Lennart E. Nacke. 2020. HexArcade: Predicting Hexad User Types By Using Gameful Applications. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (Virtual Event, Canada) *(CHI PLAY '20)*. Association for Computing Machinery, New York, NY, USA, 219–230. doi:10.1145/3410404.3414232

[4] A. R. Artino. 2008. Motivational beliefs and perceptions of instructional quality: predicting satisfaction with online training. *Journal of Computer Assisted Learning* 24, 3 (2008), 260–270. doi:10.1111/j.1365-2729.2007.00258.x

[5] Shurui Bai, Khe Foon Hew, and Biyun Huang. 2020. Does gamification improve student learning outcome? Evidence from a meta-analysis and synthesis of qualitative data in educational contexts. *Educational Research Review* 30 (2020), 100322. doi:10.1016/j.edurev.2020.100322

[6] Shurui Bai, Khe Foon Hew, Michael Sailer, and Chengyuan Jia. 2021. From top to bottom: How positions on different types of leaderboard may affect fully online student learning performance, intrinsic motivation, and course engagement. *Computers & Education* 173 (2021), 104297. doi:10.1016/j.compedu.2021.104297

[7] Martin Böckle, Isabel Micheel, Markus Bick, and Jasminko Novak. 2018. A design framework for adaptive gamification applications. *Proceedings of the 51st HICSS* (2018). http://hdl.handle.net/10125/50038

[8] Ivar Bråten and Bodil S. Olaussen. 2005. Profiling individual differences in student motivation: A longitudinal cluster-analytic study in different academic contexts. *Contemporary Educational Psychology* 30, 3 (2005), 359–396. https://www.sciencedirect.com/science/article/pii/S0361476X05000044

[9] Ilaria Caponetto et al. 2014. Gamification and education: A literature review. In *8th European Conference on Games-Based Learning - ECGBL*. https://hdl.handle.net/20.500.14243/226324

[10] Jianguo Chen, Huijuan Lu, Lixin An, and Yongxia Zhou. 2009. Exploring teaching methods in software engineering education. In *2009 4th International Conference on Computer Science & Education*. 1733–1738. doi:10.1109/ICCSE.2009.5228269

[11] Dai Clegg and Richard Barker. 1994. *Case Method Fast-Track: A Rad Approach*. Addison-Wesley Longman Publishing Co., Inc., USA.

[12] Claudio G. Cortese. 2005. Learning through Teaching. *Management Learning* 36, 1 (2005), 87–115. doi:10.1177/1350507605049905

[13] Tyne Crow, Andrew Luxton-Reilly, and Burkhard Wuensche. 2018. Intelligent Tutoring Systems for Programming Education: A Systematic Review. In *Proceedings of the 20th Australasian Computing Education Conference (ACE '18)*. Association for Computing Machinery, New York, NY, USA. doi:10.1145/3160489.3160492

[14] Eden Dahlstrom, D. Christopher Brooks, and Jacqueline Bichsel. 2014. The current ecosystem of learning management systems in higher education: Student, faculty, and IT perspectives. (2014).

[15] Marjorie Delbaere, Edward F. McQuarrie, and Barbara J. Phillips. 2011. Personification in Advertising. *Journal of Advertising* 40, 1 (2011), 121–130. doi:10.2753/JOA0091-3367400108

[16] Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke. 2011. From game design elements to gamefulness: defining "gamification". In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments (MindTrek '11)*. doi:10.1145/2181037.2181040

[17] Darina Dicheva, Christo Dichev, Gennady Agre, and Galia Angelova. 2015. Gamification in Education: A Systematic Mapping Study. *Journal of Educational Technology & Society* (2015). http://www.jstor.org/stable/jeductechsoci.18.3.75

[18] Justine Ferrer et al. 2022. Students' motivation and engagement in higher education: the importance of attitude to online learning. *Higher Education* 83, 2 (01 Feb 2022), 317–338. doi:10.1007/s10734-020-00657-5

[19] Stanley Frager and Carolyn Stern. 1970. Learning by Teaching. *The Reading Teacher* 23, 5 (2025/09/09/ 1970), 403–417. http://www.jstor.org/stable/20196333

[20] Christopher Groening and Carmen Binnewies. 2019. "Achievement unlocked!" - The impact of digital achievements as a gamification element on motivation and performance. *Computers in Human Behavior* (2019). doi:10.1016/j.chb.2019.02.026

[21] Stuart Hallifax, Audrey Serna, Jean-Charles Marty, and Élise Lavoué. 2019. Adaptive Gamification in Education: A Literature Review of Current Trends and Developments. In *Transforming Learning with Meaningful Technologies*. Springer International Publishing, Cham, 294–307.

[22] Juho Hamari, Jonna Koivisto, and Harri Sarsa. 2014. Does Gamification Work? – A Literature Review of Empirical Studies on Gamification. In *2014 47th Hawaii International Conference on System Sciences*. doi:10.1109/HICSS.2014.377

[23] Maggie Hartnett. 2016. *Motivation in online education*. Springer.

[24] Muhammad Awais Hassan, Ume Habiba, Fiaz Majeed, and Muhammad Shoaib. 2021. Adaptive gamification in e-learning based on students' learning styles. *Interactive Learning Environments* (2021). doi:10.1080/10494820.2019.1588745

[25] Wendy Hsin-Yuan Huang and Dilip Soman. 2013. Gamification of education. *Report Series: Behavioural Economics in Action* 29, 4 (2013), 37.

[26] Gabriela Kiryakova, Nadezhda Angelova, and Lina Yordanova. 2014. Gamification in education. In *Proceedings of 9th international Balkan education and science conference*, Vol. 1. 679–684.

[27] Antti Knutas et al. 2019. A process for designing algorithm-based personalized gamification. *Multimedia Tools and Applications* 78, 10 (01 May 2019), 13593–13612. doi:10.1007/s11042-018-6913-5

[28] Serhii S. Korniienko, Pavlo V. Zahorodko, Andrii M. Striuk, and Andrey I. Kupin. 2024. A systematic review of gamification in software engineering education. In *CEUR Workshop Proceedings*.

[29] Jeanine Krath, Maximilian Altmeyer, Gustavo F. Tondello, and Lennart E. Nacke. 2023. Hexad-12: Developing and Validating a Short Version of the Gamification User Types Hexad Scale. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 677, 18 pages. doi:10.1145/3544548.3580968

[30] Richard N. Landers, Kristina N. Bauer, and Rachel C. Callan. 2017. Gamification of task performance with leaderboards: A goal setting experiment. *Computers in Human Behavior* 71 (2017), 508–515. doi:10.1016/j.chb.2015.08.008

[31] Patrick Lewis et al. 2020. Retrieval-Augmented Generation for Knowledge-Intensive NLP Tasks. In *Advances in Neural Information Processing Systems*, H. Larochelle, M. Ranzato, R. Hadsell, M.F. Balcan, and H. Lin (Eds.), Vol. 33. Curran Associates, Inc., 9459–9474. https://proceedings.neurips.cc/paper_files/paper/2020/file/6b493230205f780e1bc26945df7481e5-Paper.pdf

[32] Andrzej Marczewski. 2015. User types. *Even ninja monkeys like to play: Gamification, game thinking and motivational design* 1 (2015), 65–80.

[33] Niklas Meißner, Paul Bredl, Sandro Speth, and Steffen Becker. 2025. Enhancing Motivation in Software Engineering Education through Gamified Agile Project-based Learning. In *Proceedings of the 33rd ACM International Conference on the Foundations of Software Engineering (FSE Companion '25)*. Association for Computing Machinery, New York, NY, USA, 835–846. doi:10.1145/3696630.3727241

[34] Niklas Meißner. 2024. MEITREX - Gamified and Adaptive Intelligent Tutoring in Software Engineering Education. In *46th International Conference on Software Engineering (ICSE-Companion '24)*. doi:10.1145/3639478.3639804

[35] Niklas Meißner et al. 2024. Unveiling Hurdles in Software Engineering Education: The Role of Learning Management Systems. In *Proceedings of the 46th International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET '24)*. doi:10.1145/3639474.3640060

[36] Baptiste Monterrat, Michel Desmarais, Élise Lavoué, and Sébastien George. 2015. A Player Model for Adaptive Gamification in Learning Environments. In *Artificial Intelligence in Education*. Springer International Publishing, Cham, 297–306.

[37] Fiona Fui-Hoon Nah et al. 2014. Gamification of Education: A Review of Literature. In *HCI in Business*, Fiona Fui-Hoon Nah (Ed.). Springer International Publishing, Cham, 401–409.

[38] Sofia Ouhbi and Nuno Pombo. 2020. Software Engineering Education: Challenges and Perspectives. In *2020 IEEE Global Engineering Education Conference (EDUCON)*. 202–209. doi:10.1109/EDUCON45650.2020.9125353

[39] Sungjin Park and Sangkyun Kim. 2021. Leaderboard Design Principles to Enhance Learning and Motivation in a Gamified Educational Environment: Development Study. *JMIR Serious Games* 9, 2 (20 Apr 2021), e14746. doi:10.2196/14746

[40] Klaus Pohl and Chris Rupp. 2011. *Requirements Engineering Fundamentals: A Study Guide for the Certified Professional for Requirements Engineering Exam - Foundation Level - IREB compliant* (1st ed.). Rocky Nook.

[41] Oki Priyadi et al. 2023. Gamification in Software Development: Systematic Literature Review. In *Emerging Trends in Intelligent Systems & Network Security*. Springer International Publishing, Cham, 386–398.

[42] Luiz Rodrigues et al. 2021. Personalized gamification: A literature review of outcomes, experiments, and approaches. In *Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'20)*. Association for Computing Machinery, New York, NY, USA. doi:10.1145/3434780.3436665

[43] Pedro Rodrigues, Mauricio Souza, and Eduardo Figueiredo. 2018. Games and Gamification in Software Engineering Education: A Survey with Educators. In *2018 IEEE Frontiers in Education Conference (FIE)*. doi:10.1109/FIE.2018.8658524

[44] Gustavo F. Tondello et al. 2016. The Gamification User Types Hexad Scale. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '16)*. Association for Computing Machinery, New York, NY, USA, 229–243. doi:10.1145/2967934.2968082

[45] Gustavo F. Tondello, Alberto Mora, and Lennart E. Nacke. 2017. Elements of Gameful Design Emerging from User Preferences. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (Amsterdam, The Netherlands) *(CHI PLAY '17)*. Association for Computing Machinery, New York, NY, USA, 129–142. doi:10.1145/3116595.3116627

[46] Gustavo F. Tondello and Lennart E. Nacke. 2020. Validation of User Preferences and Effects of Personalized Gamification on Task Performance. *Frontiers in Computer Science* Volume 2 - 2020 (2020). doi:10.3389/fcomp.2020.00029

[47] Kurt VanLehn. 2006. The Behavior of Tutoring Systems. *International Journal of Artificial Intelligence in Education* 16, 3 (2006). doi:10.3233/IRG-2006-16(3)02

[48] J. M. Verner et al. 2014. Factors that motivate software engineering teams: A four country empirical study. *Journal of Systems and Software* 92 (2014), 115–127. doi:10.1016/j.jss.2014.01.008

[49] Boban Vesin, Katerina Mangaroska, and Michail Giannakos. 2018. Learning in smart environments: user-centered design and analytics of an adaptive learning system. *Smart Learning Environments* (2018). doi:10.1186/s40561-018-0071-0

[50] Jin Wang and Wenxiang Fan. 2025. The effect of ChatGPT on students' learning performance, learning perception, and higher-order thinking: insights from a meta-analysis. *Humanities and Social Sciences Communications* 12, 1 (06 May 2025), 621. doi:10.1057/s41599-025-04787-y

[51] Wang Yongxing. 2008. Blended Learning Design for Software Engineering Course Design. In *2008 International Conference on Computer Science and Software Engineering*, Vol. 5. 345–348. doi:10.1109/CSSE.2008.198

[52] Nilüfer Zeybek and Elif Saygı. 2024. Gamification in Education: Why, Where, When, and How?—A Systematic Review. *Games and Culture* 19, 2 (2024), 237–264. doi:10.1177/15554120231158625