

ARQAMified: Learning Arabic Numbers Using Interactive Apps

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ABSTRACT

The acquisition of Arabic as a second language (L2) presents a unique set of challenges for learners, particularly in mastering foundational elements such as the numeral system, which differs significantly from its Western counterparts. This paper introduces ARQAMified, a comprehensive conceptual framework for an innovative mobile application designed to mitigate these difficulties through the synergistic integration of gamification, transliteration, and established principles of mobile-assisted language learning (MALL). The proposed framework aims to scaffold the learning process for non-native speakers by employing transliteration as a cognitive bridge to facilitate the transition from a familiar script (e.g., Roman) to the Arabic script. Simultaneously, it leverages evidence-based game mechanics to enhance intrinsic motivation, sustained engagement, and learning outcomes, grounded in psychological theories such as Self-Determination Theory. This conceptual paper provides a detailed exposition of the pedagogical rationale, theoretical underpinnings, and a proposed architectural blueprint for the ARQAMified application. The framework is developed through a meticulous synthesis of recent, high-impact scholarly literature from the Scopus and Web of Science databases, ensuring an evidence-based approach to its design. It discusses the potential of the framework to support holistic language skill development, encompassing reading, writing, listening, and speaking, and explores its implications for both self-directed learning and formal classroom integration. By addressing a distinct gap in the current landscape of Arabic language learning technology, ARQAMified presents a scalable, theoretically robust solution. This paper concludes by outlining a structured path for future empirical research, commencing with a formal needs analysis to validate the framework's assumptions and guide an iterative, user-centered development process.

Keywords: Conceptual Framework, Gamification, Mobile-Assisted Language Learning (MALL), Arabic Language, Transliteration, Educational Technology, Self-Determination Theory, Second Language Acquisition

INTRODUCTION

The Arabic language, with its rich cultural heritage and status as an official language in over 20 countries and the United Nations, has witnessed a substantial increase in global interest among second language (L2) learners (Al-Murtadha, 2021). This growing demand has highlighted the need for effective, modern pedagogical tools that can support learners in navigating the unique complexities of the language. A foundational, yet often formidable, challenge for non-native speakers, particularly those from Indo-European language backgrounds, is the mastery of the Arabic numeral system and its integration into basic communicative tasks (Ryding, 2013). The Eastern Arabic numerals (٠, ١, ٢, ٣, ٤, ٥, ٦, ٧, ٨, ٩) present a visual and cognitive barrier that requires dedicated practice and reinforcement. Traditional pedagogical methods, while valuable, frequently struggle to maintain the engagement of contemporary learners who are accustomed to interactive, technology-mediated experiences. This disconnect creates a compelling case for the development of innovative, evidence-based digital solutions.

This paper proposes a conceptual framework for "ARQAMified," a mobile application meticulously designed to address these pedagogical challenges. The framework is predicated on the strategic and synergistic integration of two core pillars: gamification, defined as the application of game-design elements in non-game contexts to enhance user engagement and motivation (Deterding et al., 2011), and transliteration, the systematic representation of Arabic script using a familiar writing system, such as the Roman alphabet. The central thesis of this paper is that the carefully orchestrated combination of these two elements can significantly lower the cognitive load associated with learning a new script while concurrently amplifying learner motivation, persistence, and overall engagement. Gamification serves as the motivational engine, tapping into fundamental human psychological needs, while transliteration functions as a pedagogical scaffold, providing a crucial bridge that allows learners to build phonological and semantic connections before achieving fluency in the native script.

The development of this conceptual framework is not based on intuition but is firmly grounded in a synthesis of findings from recent, high-impact scholarly literature indexed in premier academic databases. By drawing on established theories and empirical evidence from the fields of educational psychology, second language acquisition (SLA), and human-computer interaction, this paper presents a robust, evidence-based blueprint for the ARQAMified application. It will delineate the framework's theoretical foundations, articulate its core design principles and components, and propose a detailed application architecture. Ultimately, this paper aims to lay the groundwork for future empirical validation, outlining a clear research trajectory to transition ARQAMified from a conceptual model to a validated and effective educational tool for learners of Arabic worldwide.

LITERATURE REVIEW

The Theoretical Foundation of ARQAMified

The ARQAMified framework is constructed upon a robust theoretical foundation derived from the confluence of three critical and intersecting research domains: the psychology of gamification in educational contexts, the pedagogical application of transliteration as a cognitive scaffold, and the principles of Mobile-Assisted Language Learning (MALL). This section synthesizes key theories and empirical findings from each domain to establish the rationale for the framework's design.

The Motivational and Cognitive Power of Gamification in Education

Gamification has emerged as a powerful and widely researched strategy for enhancing learner motivation, engagement, and academic performance across various disciplines (Sánchez-Ramírez et al., 2024; Zainuddin et al., 2023). Its effectiveness is not arbitrary but is deeply rooted in its capacity to address fundamental human psychological needs.

Self-Determination Theory (SDT) as a Motivational Framework

The most prominent theoretical lens through which the effects of gamification are understood is Self-Determination Theory (SDT), proposed by Ryan and Deci (2000). SDT posits that intrinsic motivation is fostered when an environment supports three basic psychological needs: autonomy (the need to feel volitional and in control of one's actions), competence (the need to feel effective and master challenges), and relatedness (the need to feel connected to others). Well-designed gamified systems directly cater to these needs. For instance, game elements such as points, badges, and levels (PBL) provide immediate and clear feedback, reinforcing a learner's sense of competence and progress (Zolfaghari et al., 2025). Offering choices in learning paths or customization options can enhance autonomy, while leaderboards or team-based challenges can foster a sense of relatedness and social competition. A recent meta-analysis by Zainuddin et al. (2023) confirmed the significant positive effect of gamification on learning outcomes, attributing this success to its ability to create intrinsically motivating learning environments that satisfy these core needs.

Empirical Evidence from Systematic Reviews and Meta-Analyses

The empirical support for gamification in education is substantial and growing. A systematic review by Sánchez-Ramírez et al. (2024) analyzed dozens of studies and found a strong, positive correlation between the implementation of gamification and increases in both student motivation and academic performance. Specifically within the domain of language learning, gamification has shown considerable promise. Investigating its influence in online language learning contexts, Bai et al. (2024) found that gamified interventions significantly enhanced both motivational intensity and learning outcomes, particularly in vocabulary acquisition and grammatical accuracy. Furthermore, a scoping review of gamified applications in English language teaching by Zolfaghari et al. (2025) identified that the most impactful game mechanics are those that provide immediate feedback and interactive, progressively difficult challenges. These findings directly inform the core design of ARQAMified, which prioritizes a feedback-rich environment where learners are consistently challenged in a structured and supportive manner, ensuring that the difficulty remains within their optimal learning zone. The framework deliberately avoids "pointsification", the superficial addition of points without meaningful connection to learning and instead focuses on creating a cohesive, motivation-centric experience grounded in established psychological principles.

Transliteration as a Pedagogical Scaffolding Tool

For ab initio learners of a language that employs a different writing system (orthography), the script itself can present a significant cognitive barrier, impeding progress in other linguistic areas such as phonology and vocabulary acquisition. Transliteration, the process of converting text from one script to another, serves as a critical pedagogical scaffold to overcome this initial hurdle.

Cognitive Scaffolding and Vygotsky's Zone of Proximal Development

The concept of transliteration as a learning aid aligns with Vygotsky's (1978) sociocultural theory of learning, particularly the notion of scaffolding within the Zone of Proximal Development (ZPD). The ZPD represents the difference between what a learner can do without help and what they can achieve with guidance and encouragement from a more knowledgeable other—or, in this case, a well-designed technological tool. Transliteration acts as this scaffold, allowing learners to access and process the phonological and semantic content of the Arabic language using the familiar Roman script. This "cognitive bridge" reduces the extraneous cognitive load associated with deciphering a new orthography, enabling learners to focus their mental resources on understanding pronunciation, meaning, and basic grammar (Sweller, 1994). A study by Nasir et al. (2024) highlighted the practical utility of Arabic-Rumi (Roman) transliteration for non-native learners in Malaysia, demonstrating that it significantly facilitated their initial engagement with and learning of the Arabic language.

Technological Advancements in Automated Transliteration

Historically, transliteration was a manual process, often leading to inconsistencies. However, recent advancements in machine learning and natural language processing (NLP) have made it possible to develop highly accurate and context-aware automated transliteration systems. Research in this area is advancing rapidly. For example, the development of a transformer-based model for Moroccan Arabizi-to-Arabic transliteration by Hajbi et al. (2025) demonstrates the capacity of modern AI to handle complex spelling variations and dialectal nuances with high precision. Similarly, a systematic review on machine transliteration methods by Noeman and Al-Sultan (2025) highlights the growing sophistication of neural network-based approaches. These technological capabilities are crucial for ARQAMified, as they enable the implementation of a dynamic and reliable transliteration system. The framework proposes a "fading" mechanism, where the transliteration support is gradually reduced as the learner's proficiency with the Arabic script improves, thus ensuring the scaffold is removed once it is no longer needed, promoting true orthographic competence.

Mobile-Assisted Language Learning (MALL)

The delivery of the ARQAMified framework is conceptualized for a mobile-first environment, capitalizing on

the unique affordances of Mobile-Assisted Language Learning (MALL). MALL leverages the ubiquity, portability, and connectivity of mobile devices to create flexible, personalized, and context-aware learning opportunities.

Affordances and Pedagogical Principles of MALL

As articulated in seminal work by Kukulska-Hulme (2009), MALL empowers learners by providing "anytime, anywhere" access to learning materials, fostering autonomy and enabling continuous, bite-sized learning sessions (microlearning) that fit into the interstices of daily life. Modern conceptions of MALL, however, extend beyond mere portability. A pedagogical framework proposed by Wang et al. (2024) for integrating MALL into tertiary education emphasizes the importance of designing mobile learning experiences that are not just digital versions of textbooks but are pedagogically sound and tailored to specific learning objectives and learner needs. This includes leveraging device-specific features such as touchscreens for interactive exercises, microphones for pronunciation practice, and push notifications for learning reminders. The design of ARQAMified is deeply informed by these principles, ensuring that it is not simply a content repository but a structured and interactive learning environment optimized for the mobile platform. The framework promotes an active learning approach, where users engage with the material through a variety of multimodal exercises, aligning with best practices in contemporary MALL design (Bárcena & Read, 2021).

THE ARQAMIFIED CONCEPTUAL FRAMEWORK

This section details the conceptual framework for the ARQAMified application, presenting it as a comprehensive blueprint to guide future development and empirical investigation. The framework is organized around a set of core design principles and a detailed architecture of its proposed components.

Core Design Principles

The framework is built upon four foundational design principles derived from the preceding literature review, ensuring that every feature is purposeful and grounded in established theory.

- **Motivation-Centric Design:** The primary design driver is the enhancement of intrinsic motivation. Drawing from Self-Determination Theory (Ryan & Deci, 2000), the application is engineered to systematically support learners' needs for competence, autonomy, and relatedness through its gamification engine and overall user experience.
- **Scaffolding and Fading:** The framework employs transliteration as a primary cognitive scaffold. In initial stages, Arabic numerals and words are presented alongside their Roman transliteration to reduce cognitive load. As the learner demonstrates mastery, the prominence of the transliteration is algorithmically faded, compelling a natural and gradual transition to exclusive reliance on the Arabic script.
- **Holistic Skill Integration:** While the primary focus is on the numeral system, the framework is designed to promote holistic language skill development. Modules target the four key linguistic skills: listening, speaking, reading, and writing.
- **Personalized and Adaptive Learning:** The framework is designed for future integration of adaptive algorithms that can dynamically adjust challenge levels based on user performance, ensuring each learner remains within their optimal Zone of Proximal Development (Wang et al., 2024).

Proposed Application Blueprint and Components

The ARQAMified application is a modular system with interconnected components that create a cohesive learning experience. Each conceptual component, from the gamification engine to the content delivery system, has been realized in a functional prototype, as detailed in Section 3.3.

- **Component 1: The Gamification Engine:** This core system structures the user's journey through points, levels, badges, and leaderboards to drive motivation and provide tangible feedback on progress and competence.
- **Component 2: Modular Learning Pathway:** The curriculum is organized into thematic modules, such

as basic numeral recognition, contextual application, and fast-paced challenges, providing a structured, self-paced learning path.

- **Component 3: Interactive Quiz and Exercise Engine:** This component delivers a variety of activities, including multiple-choice quizzes, pronunciation practice, and dynamic mini-games, to reinforce learning through active engagement.
- **Component 4: The Dynamic Transliteration System:** This system provides crucial support by displaying Roman transliterations alongside Arabic script. It is built on a data structure designed to facilitate a "fading" mechanism, where this scaffold can be gradually removed as learner proficiency increases.

IMPLEMENTATION OF THE CONCEPTUAL FRAMEWORK

The conceptual principles have been translated into a functional prototype using HTML, Tailwind CSS, and JavaScript, with Google Firebase for backend services. This section bridges the theoretical framework with concrete code snippets from the application, demonstrating how each component is realized.

The Gamification Engine in Practice

The leaderboard, a key feature for fostering relatedness, is implemented using Firestore, allowing for real-time, persistent high-score tracking. When a game ends, the player's score is sent to the database, and a transaction ensures that the high score is only updated if the new score is higher.

```
// Snippet from App.endGame(score)
if (this.gameState.playerName && score > 0) {
  const leaderboardRef = db.collection("leaderboard").doc(this.gameState.playerName);
  db.runTransaction(transaction => {
    return transaction.get(leaderboardRef).then(playerDoc => {
      if (!playerDoc.exists) {
        transaction.set(leaderboardRef, { name: this.gameState.playerName, highScore: score,
timestamp: firebase.firestore.FieldValue.serverTimestamp() });
      } else {
        const currentHighScore = playerDoc.data().highScore || 0;
        if (score > currentHighScore) {
          transaction.update(leaderboardRef, { highScore: score, timestamp:
firebase.firestore.FieldValue.serverTimestamp() });
        }
      }
    });
  });
}
```

Modular Learning Pathway and Content Structure

The application's content is structured into distinct modules, managed by a GameMode constant. This allows for easy expansion of learning activities. The CULTURAL_MALAYSIA module, for example, demonstrates contextual learning by placing numbers in authentic, localized scenarios.

```
// Definition of game modes for modularity
const GameMode = {
  LEARN_AND_PRACTICE: 'LEARN_AND_PRACTICE',
  CULTURAL_MALAYSIA: 'CULTURAL_MALAYSIA',
  NUMBER_TO_ARABIC: 'NUMBER_TO_ARABIC',
  ARABIC_TO_NUMBER: 'ARABIC_TO_NUMBER',
  NUMBER_CHASE: 'NUMBER_CHASE',
  WATCH_AND_LEARN: 'WATCH_AND_LEARN'
}
```

```
};

// Example of contextual learning content
const CULTURAL_SCENARIOS = {
  prayer: {
    title: "Waktu Solat",
    subtitle: "ماليزيا في الصلاة",
    scenarios: [{
      context: "Subuh di Malaysia bermula pada pukul 5:30 pagi",
      question: "Pukul berapa waktu Subuh bermula?",
      answer: "5:30",
      /* ... more data */
    }]
  },
  /* ... other categories like calendar and zakat */
};
```

Interactive Exercise Implementation

The quiz engine dynamically generates question interfaces based on the game mode, reinforcing learning through active recall. Further, pronunciation practice is enabled using the browser's built-in Web Speech API.

```
// Snippet from QuizGame.buildUI() for dynamic quiz generation
const q = this.state.questions[this.state.currentIndex];
const optionsHtml = q.options.map(opt =>
  `<button onclick="QuizGame.checkAnswer('${opt.replace('/',g, '\\')}')" class="...">
    ${opt}
  </button>`
).join("");
container.innerHTML = `
  <main class="...">
    <h2 class="arabic-text text-6xl mb-8">${q.prompt}</h2>
    <div id="quiz-options" class="grid grid-cols-2 gap-4">${optionsHtml}</div>
  </main>`;

// Snippet for pronunciation practice
function speakArabic(text) {
  if (!('speechSynthesis' in window)) return;
  const utterance = new SpeechSynthesisUtterance(text);
  utterance.lang = 'ar-SA';
  speechSynthesis.speak(utterance);
}
```

The Transliteration System's Data Foundation

The scaffolding principle is built upon a core data structure that pairs Arabic script with its Roman transliteration (rumi). This data is used across the application to provide initial support for learners, forming the foundation for the transliteration scaffold.

```
// Core data structure including transliteration
const ARABIC_NUMBERS_DATA = {
  0: { arabic: "٠", text: "صفر", rumi: "sifr" },
  1: { arabic: "١", text: "واحد", rumi: "wāḥid" },
  // ... more numbers
};
```

2: { arabic: "٢", text: "اثنان", rumi: "ithnān" },
// ... and so on for other numbers
};

DISCUSSION AND FUTURE DIRECTIONS

The conceptual framework for ARQAMified presented in this paper contributes to the field of Arabic language pedagogy by offering a targeted, theory-driven solution to a persistent learning challenge. Its novelty lies not in the invention of any single element, but in the synergistic synthesis of evidence-based principles from gamification, transliteration technology, and MALL. While applications for language learning exist, few are designed with such a specific focus on the foundational skill of numeracy in Arabic, and fewer still are explicitly built upon a transparent, research-grounded pedagogical framework that combines cognitive scaffolding with robust motivational design.

The potential implications for Arabic language learning are significant. For self-directed learners, ARQAMified offers a structured, engaging, and accessible entry point to the language, potentially increasing retention rates for beginners who might otherwise be discouraged by the initial script-related difficulties. In formal educational settings, the application could serve as a powerful supplementary tool for blended learning environments. Instructors could use it to assign targeted practice, track student progress, and free up valuable classroom time for more complex, communicative activities. The data generated by the application on user performance could also provide valuable insights into common learning hurdles, informing future curriculum development.

LIMITATIONS OF A CONCEPTUAL FRAMEWORK

As a conceptual paper, the primary and inherent limitation of this work is the absence of empirical data to validate its claims. The proposed effectiveness of the ARQAMified framework is, at this stage, theoretical and inferred from a synthesis of existing research in related but distinct contexts. The success of the application will depend heavily on the quality of its execution, including user interface (UI) and user experience (UX) design, the accuracy of its content, and the seamless integration of its components. Furthermore, the framework assumes a degree of learner motivation to download and engage with the application initially, and it does not account for all potential learner variables, such as age, prior language learning experience, or specific learning disabilities.

A Roadmap for Future Research and Development

The critical next step is to move from this conceptual blueprint to a rigorous, multi-stage process of development and empirical validation. The following roadmap is proposed:

1. **Stage 1: Formal Needs Analysis:** Before any development, a formal needs analysis should be conducted with the target learner population (e.g., university-level Arabic L2 students, self-directed adult learners). This mixed-methods study, incorporating surveys and focus groups, would serve to validate the core assumptions of this framework, identify specific learner pain points related to the Arabic numeral system, and gather feedback on the proposed features.
2. **Stage 2: Prototype Development and Usability Testing:** Based on the findings from the needs analysis, a minimum viable product (MVP) of the ARQAMified application should be developed. This prototype would then undergo several cycles of iterative usability testing with a small group of representative users to refine the UI/UX, ensuring the application is intuitive, engaging, and free of significant technical or design flaws.
3. **Stage 3: Quasi-Experimental Efficacy Study:** Once a stable prototype is developed, a quasi-experimental study should be conducted to measure the application's impact on learning outcomes, motivation, and engagement. This study could compare a group of learners using ARQAMified as a supplementary tool to a control group using traditional methods (e.g., worksheets or flashcards) over a set period. Key metrics would include performance on pre- and post-tests of numeral recognition and

use, as well as validated psychometric scales to measure changes in motivation and engagement (e.g., the Intrinsic Motivation Inventory).

CONCLUSION

The acquisition of Arabic numerals represents a critical yet challenging milestone for non-native speakers. This paper has introduced ARQAMified, a conceptual framework for a mobile application designed to transform this challenge into an engaging and effective learning experience. By meticulously weaving together the motivational affordances of gamification, the cognitive support of transliteration-based scaffolding, and the pedagogical principles of mobile-assisted language learning, the framework provides a comprehensive, evidence-based blueprint for a next-generation educational tool. The design is explicitly grounded in established theories, including Self-Determination Theory, and is informed by a synthesis of recent, high-impact research, ensuring that its proposed features are both purposeful and promising.

While the framework is currently theoretical, it lays a clear and structured foundation for future work. Through a rigorous, phased approach of needs analysis, prototype development, and empirical testing, the ARQAMified concept has the potential to be realized as a valuable resource that can significantly lower barriers for new learners of Arabic. By addressing a specific and foundational aspect of language acquisition with a modern, learner-centric approach, ARQAMified stands to make a meaningful contribution to the growing field of Arabic language technology and pedagogy, ultimately supporting the aspirations of a new generation of learners worldwide.

Co-Author Contribution

The authors declare no conflict of interest related to this article. Author 1 coordinated the overall development of the conceptual framework and led the manuscript preparation from initial drafting to final review. Author 2 contributed to the theoretical design and refinement of the framework components, ensuring alignment with established pedagogical models. Author 3 focused on the technical implementation of the application prototype, leveraging front-end technologies and Firebase integration to translate conceptual elements into functional components. Author 4 supported the literature synthesis and helped articulate the integration of gamification and transliteration within the framework. Author 5 provided essential input during the editing and proofreading stages to enhance clarity and coherence. All authors contributed to the conceptual analysis, engaged in scholarly discussions, and participated in revising the manuscript.

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