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An Interactive Web-Based Educational Platform for Learning Traditional Pulli Kolam Patterns

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ABSTRACT

Purpose

This study presents the design and development of Kolam Connect, an interactive web-based educational platform that introduces users to the traditional South Indian art of Pulli Kolam through a gamified learning experience. The system aims to preserve cultural heritage by combining digital technologies with educational game mechanics. It enables users to learn the significance of Kolam, select different difficulty levels, practice drawing patterns by connecting dots, and receive immediate visual feedback. The project seeks to improve user engagement, cultural awareness, and learning effectiveness through an intuitive and interactive interface.

Design/Methodology/Approach

The study adopts a design-oriented software development methodology using modern web technologies. The application is developed using HTML5, CSS3, JavaScript, Canvas API, and JSON for pattern management. The system architecture separates presentation, application logic, and pattern data, ensuring modularity and scalability. Interactive drawing validation is implemented through coordinate-based path matching, while Local Storage is used to maintain user progress. Multiple Kolam patterns are represented using structured JSON objects consisting of dots, paths, and metadata, enabling dynamic rendering and simplified pattern expansion.

Findings

The developed system successfully provides an engaging environment for learning traditional Pulli Kolam designs. Users are able to understand the cultural significance of Kolam, practice different geometric patterns, and receive immediate feedback regarding drawing accuracy. The modular JSON-based architecture simplifies the addition of new Kolam designs without modifying the application logic. The game-based approach improves user interaction while encouraging the preservation and appreciation of traditional Indian cultural practices through digital technology.

Originality/Value

This study contributes to the growing field of digital cultural heritage preservation by integrating traditional Kolam art with interactive educational technologies. Unlike conventional Kolam tutorials, the proposed platform provides real-time drawing validation, progressive learning,

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gamification, and structured pattern management. The system demonstrates how indigenous art forms can be preserved and taught effectively through accessible web-based applications, making cultural education more engaging for learners of different age groups.

Keywords: Cultural Heritage, Educational Game, Human-Computer Interaction, Gamification, Web Application, Pulli Kolam.

JEL Codes: A20; I20; O33

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1. Introduction

Kolam is a traditional South Indian floor art created by arranging dots and connecting them using straight or curved lines to produce symmetrical geometric patterns. Traditionally drawn at the entrance of homes using rice flour, Kolam symbolizes prosperity, harmony, and hospitality while reflecting mathematical symmetry and artistic creativity. Despite its cultural significance, younger generations are becoming less familiar with this art due to changing lifestyles and increasing dependence on digital technologies.

Educational games have emerged as an effective approach for improving engagement and knowledge retention. Interactive learning environments encourage active participation and provide immediate feedback, making learning more enjoyable compared to conventional instructional methods. However, limited digital platforms exist for preserving and teaching traditional Kolam drawing in an interactive manner.

This research introduces Kolam Connect; a web-based educational game designed to teach Pulli Kolam through guided drawing exercises. The application provides cultural information, interactive pattern selection, real-time drawing assistance, progress tracking, and immediate feedback. The study demonstrates how web technologies can preserve cultural traditions while enhancing user learning experiences through gamification.

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2. Literature Review

Digital preservation of cultural heritage has become an important research area as digital technologies increasingly support the documentation, dissemination, and learning of traditional cultural practices. Lepouras and Vassilakis (2004) demonstrated how game technologies could be used to develop virtual museum environments for cultural heritage edutainment, highlighting the potential of interactive digital platforms to make cultural content more accessible and engaging. More recently, Utkugün and Yıldırım (2024) examined virtual museums as tools for cultural heritage learning and reported that digital museum environments provide new opportunities for learners to explore and understand cultural heritage.

Gamification has also become increasingly relevant in educational environments because game-based elements can encourage learner participation, motivation, and interaction. Interactive digital environments can incorporate features such as challenges, rewards, progress indicators, feedback, and achievement mechanisms to make learning more engaging. In the context of cultural heritage education, Huang et al. (2025) investigated interactive virtual museums using extended reality and found positive effects on user experience, engagement, motivation, and cultural learning. Their findings indicate that combining cultural content with interactive and game-oriented experiences can provide new opportunities for technology-supported heritage education.

Traditional Kolam has attracted increasing attention from researchers because of its cultural significance as well as its mathematical and computational characteristics. Reddy (2023) examined Kambi Kolam as an algorithmic pattern and explored the use of computational and human-centred approaches for representing its structured drawing process. The study highlights how Kolam patterns can be understood through computational rules while retaining their cultural characteristics. More recently, Sivakumar and Sivakumar (2026) developed an algorithm for generating one-stroke Kolam patterns using a gating structure. Their work demonstrates that the geometric rules underlying Kolam can be translated into computational procedures capable of generating symmetrical patterns.

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Recent research has further demonstrated the potential of combining traditional Kolam practices with digital technologies. Ramesh and Rajabiyazdi (2026) investigated Pulli Kolam as a structured cultural practice that can be used for physical data representation, demonstrating the potential for extending traditional Kolam beyond conventional artistic applications while maintaining its underlying geometric and cultural characteristics. These studies indicate that existing research has primarily concentrated on the mathematical structure, algorithmic generation, computational representation, and digital interpretation of Kolam.

However, relatively limited attention has been given to using Kolam as an interactive cultural-learning activity that combines heritage education with gamification and real-time drawing validation. The proposed system addresses this gap by integrating cultural education, gamified learning, interactive Kolam drawing, and automated validation within a web-based environment. Such an approach can potentially move Kolam research beyond digital representation and algorithmic generation toward an interactive learning model that encourages younger users to understand, practise, and engage with the cultural heritage of traditional Kolam.

3. Methodology

The proposed system follows a modular software architecture consisting of three major components:

1. **Introduction Module**
    - Provides historical and cultural information about Kolam.
    - Explains Pulli Kolam and its significance.
    - Introduces users to the learning environment.
2. **Game Module**
    - Allows users to select levels and Kolam patterns.
    - Displays interactive dots on an HTML5 Canvas.

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- Validates user drawing paths in real time.
- Provides visual feedback and completion status.

3. **Pattern Management Module**
   - Stores Kolam patterns in a JSON file.
   - Each pattern contains:
     - Pattern ID
     - Name
     - Difficulty Level
     - Educational Fact
     - Dot Coordinates
     - Drawing Paths

The application is developed using HTML5, CSS3, JavaScript, and the Canvas API. JSON is employed for storing pattern definitions, allowing additional Kolam designs to be incorporated without modifying the application source code. Local Storage is utilized to save user progress and completed designs.

4. Research Results and Discussion

The implemented system demonstrates that traditional Kolam learning can be effectively transformed into an engaging digital experience. Users successfully complete guided drawing exercises while receiving continuous feedback regarding drawing accuracy.

The JSON-based architecture significantly improves maintainability by separating educational content from application logic. Interactive path validation ensures users follow the intended drawing sequence, thereby enhancing learning outcomes.

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The game interface encourages repeated practice and gradually improves familiarity with Kolam patterns. Compared to static tutorials, the interactive system provides greater engagement and supports self-paced learning.

Table 1. System Modules

No.	Module	Function
1.	Introduction Module	Presents Kolam history and cultural significance
2.	Pattern Selection	Allows users to choose levels and designs
3.	Interactive Canvas	Supports guided Kolam drawing
4.	Validation Engine	Checks drawing accuracy in real time
5.	Progress Tracker	Stores completed patterns using Local Storage
6.	JSON Repository	Manages Kolam pattern definitions

Source: Author's implementation.

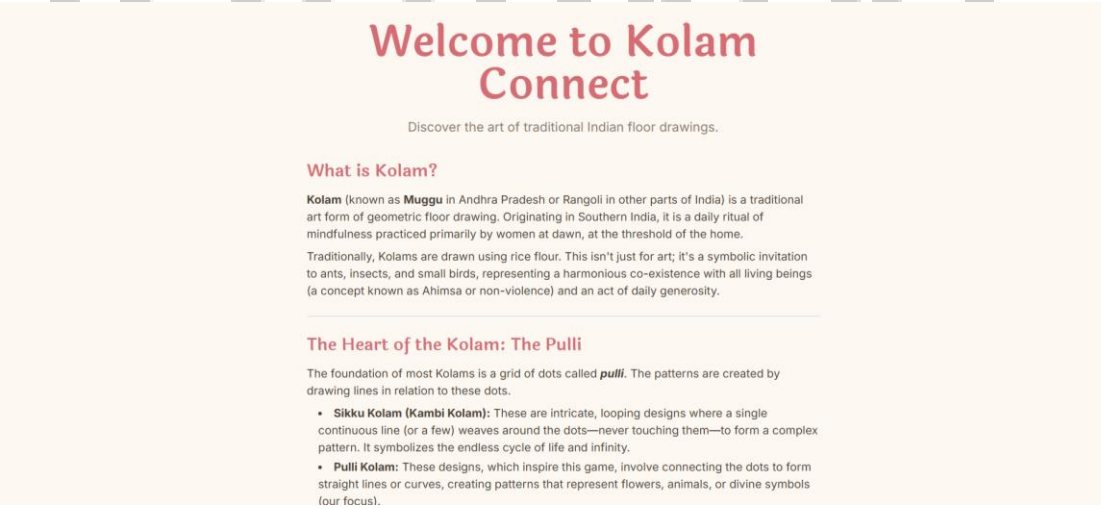

Figure 1. Introduction Page of Kolam Connect

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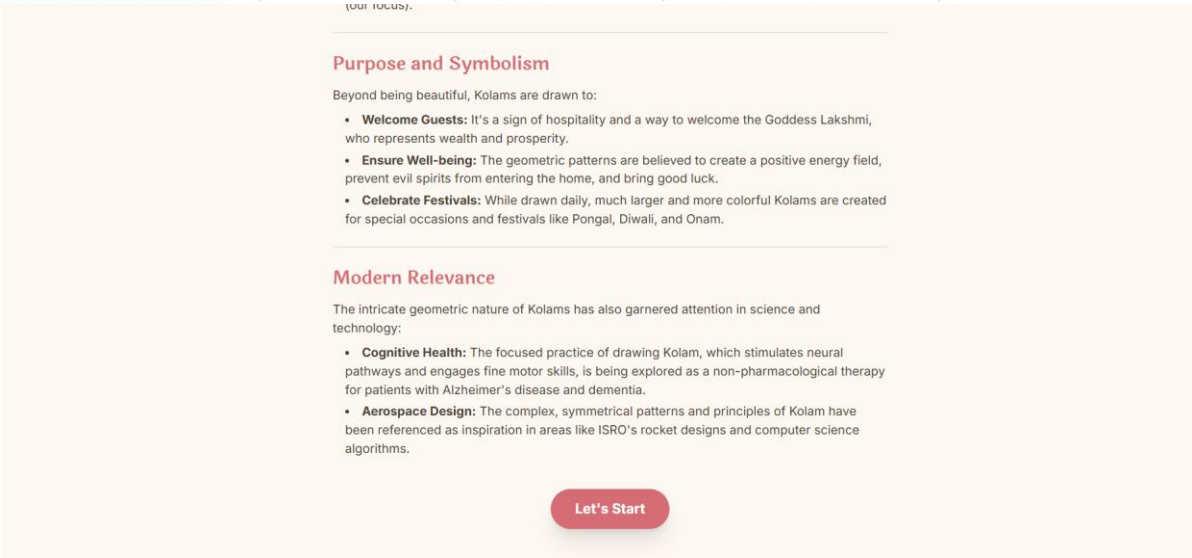

Figure 2. Introduction Page of Kolam Connect

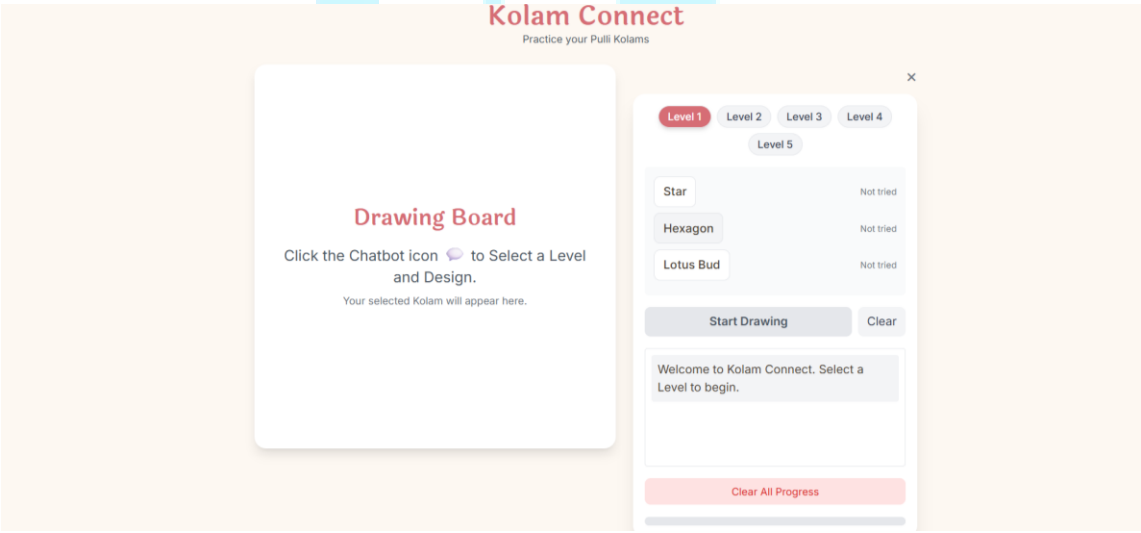

Figure 3. Drawing Board

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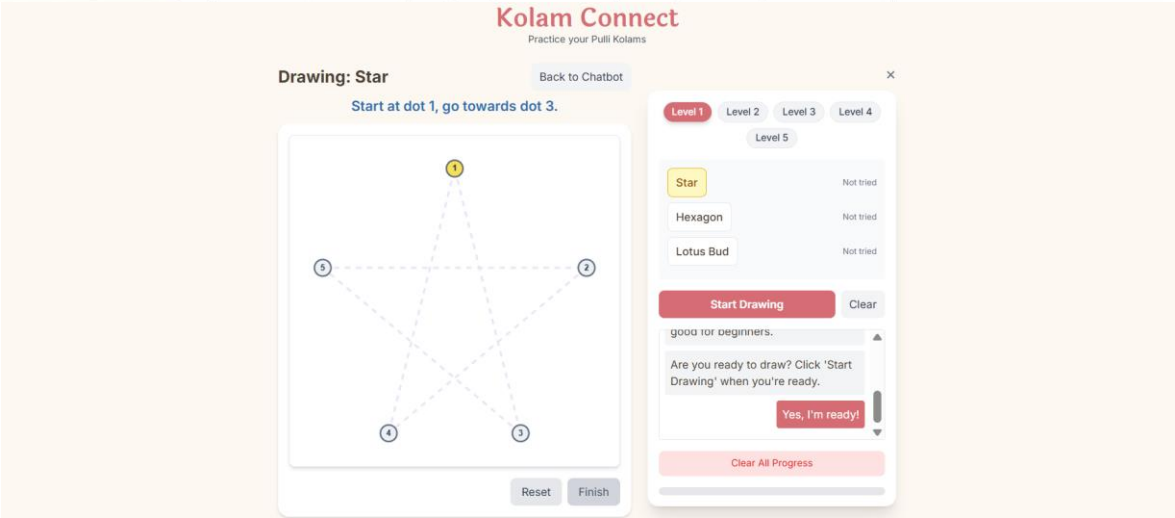

Figure 4. Chatbot and drawing area

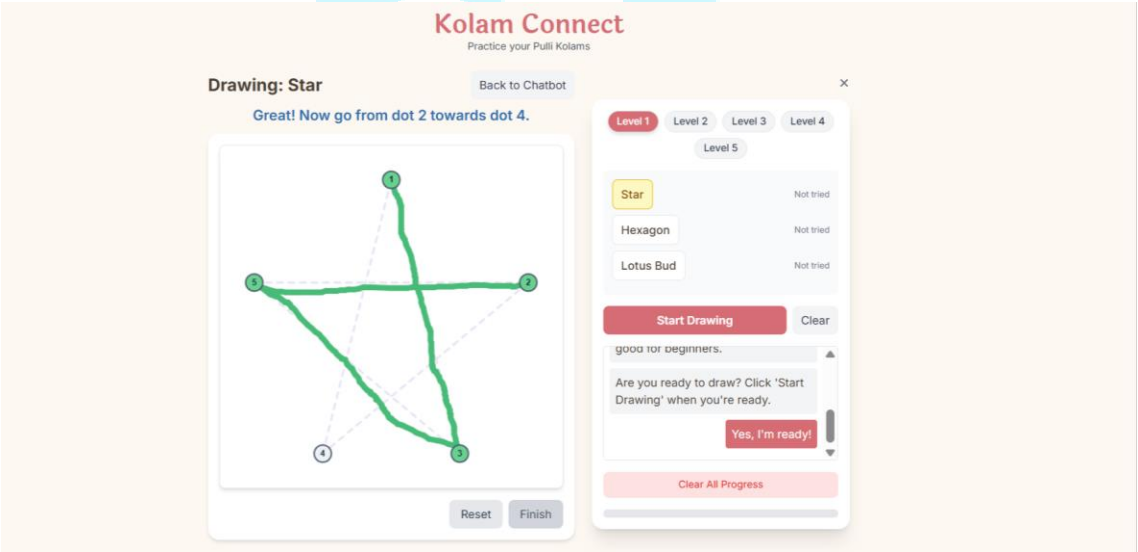

Figure 5. Level 1 - Star Kolam with Instructions

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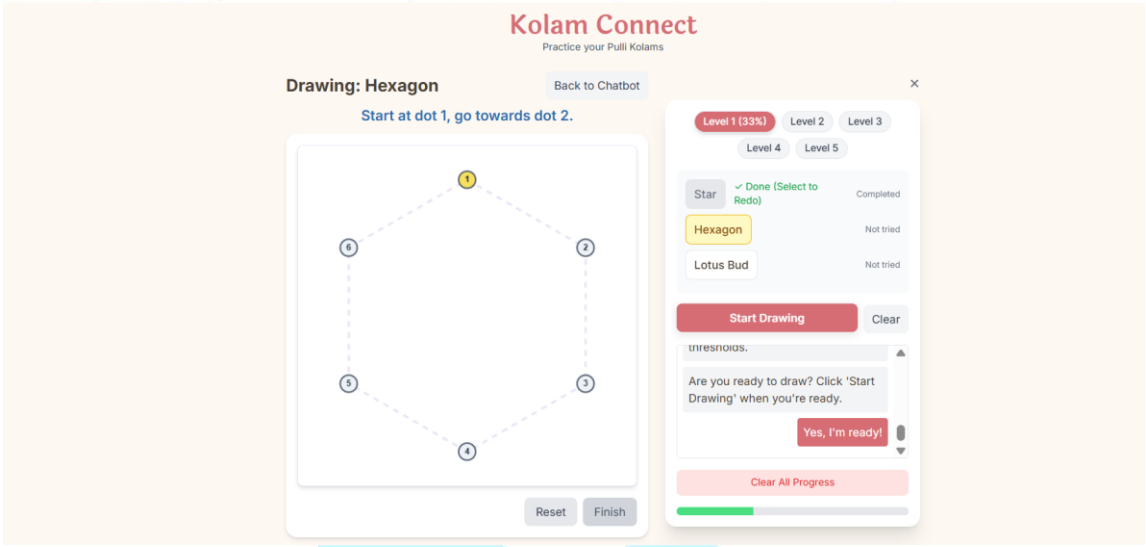

Figure 6. Level 1 - Hexagon Kolam with Instructions and Progress bar

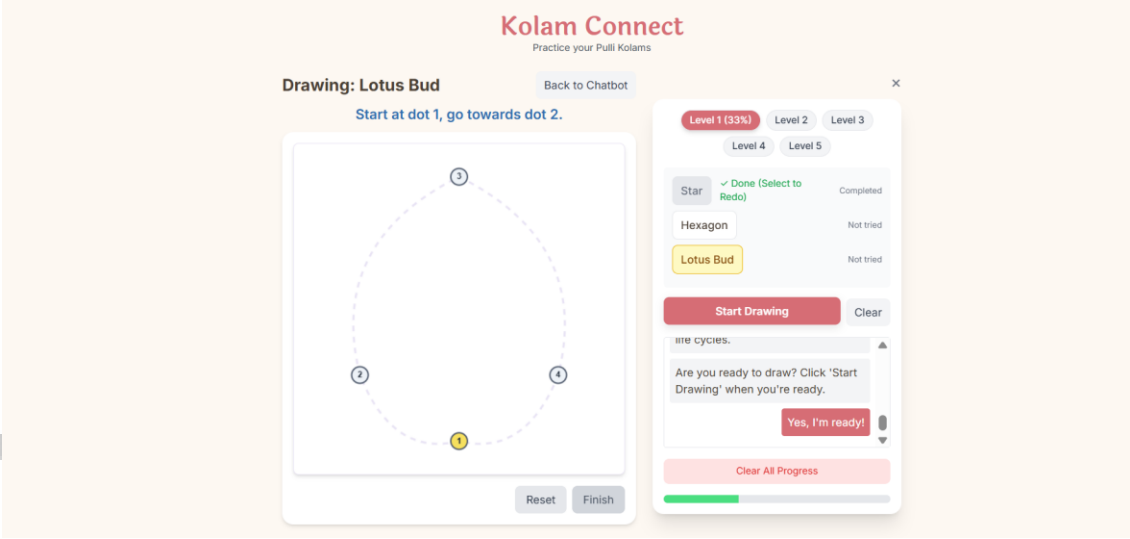

Figure 7. Level 1 – Lotus Bud Kolam with Instructions and Progress bar

5. Conclusions, Proposals, Recommendations

The proposed Kolam Connect system successfully demonstrates the integration of cultural heritage preservation with interactive web technologies. The platform enables users to understand traditional Pulli Kolam while actively practicing pattern drawing through a gamified interface. The

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modular design improves maintainability and facilitates future expansion with additional Kolam designs and learning levels.

Future enhancements may include AI-assisted stroke recognition, adaptive difficulty levels, voice-guided instructions, multilingual support, and mobile application deployment to reach a wider audience.

6. Theoretical Implications

This study contributes to digital heritage preservation by demonstrating that traditional cultural practices can be effectively represented through interactive web-based educational systems. It also illustrates how gamification principles enhance engagement in cultural learning environments.

7. Practical Implications

The proposed platform can be adopted by schools, museums, cultural organizations, and online educational platforms to promote Indian traditional art among children and international learners. Its lightweight web architecture enables easy deployment without specialized hardware or software

8. Social Implications

The application supports the preservation of traditional Indian cultural practices by making Kolam accessible to younger generations through digital technology. It encourages cultural awareness while promoting creativity, logical thinking, and appreciation for indigenous art forms.

9. Industry Implications

The project demonstrates opportunities for integrating cultural education with digital learning platforms, educational technology, museums, tourism applications, and heritage preservation

initiatives. The modular architecture also enables future commercialization as an educational web application.

10. Limitations & Scope for Future Research

The current implementation includes a limited number of beginner-level Kolam patterns and supports only predefined drawing paths. The evaluation primarily focuses on functional correctness rather than large-scale user studies.

Future work may incorporate artificial intelligence for freehand stroke recognition, personalized learning recommendations, multiplayer learning modes, accessibility features for differently abled users, cloud-based progress synchronization, and comprehensive usability evaluations involving diverse user groups.

Conflicts of Interest Declaration

- The authors declare that there are no conflicts of interest regarding the publication of this research.

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