Mobile-Assisted Informal Collaborative Learning for Irula Language Revitalisation: A Mixed-Methods Study

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Abstract

The Irula language, spoken by India's indigenous Irula tribes in the Western Ghats of Tamil Nadu, faces critical endangerment due to socioeconomic pressure and the dominance of mainstream languages. This study evaluates Mobile-Assisted Informal Collaborative Learning (MAICL) for the revitalisation of the Irula language. Employing mixed methods, the research combined quantitative and qualitative assessments involving 42 participants aged 14 to 30 from three Irula villages inNilgiri District. The MAICL intervention incorporated cultural multimedia content and gamified activities that were delivered through a mobile application. The analysis revealed significant vocabulary improvements (t(41) = 17.17, p < .001), with a mean increase of 7.5 points on a 50-item test, reflecting a 27% enhancement (Cohen's d = 1.2). The participants demonstrated high engagement, with an average of 13.5 weekly logins, a task completion rate of 78.4%, and received positive feedback (4.2/5.0). Correlation analysis revealed a relationship between the engagement metrics and vocabulary improvement (r = 0.29). The qualitative findings highlighted that gamification and opportunities for collaboration were the key factors motivating the participants. Although the study had limitations, such as the lack of a comprehensive control group and relatively small sample size, it makes a meaningful contribution by demonstrating that MAICL is effective in revitalising indigenous languages. Future studies could expand this approach to other endangered languages, evaluate its effectiveness among different age groups, and investigate the incorporation of advanced technologies such as artificial intelligence for more personalised language learning. Additionally, long-term studies are recommended to assess the ongoing retention of language and sustainability of technology-driven language learning initiatives within diverse cultural contexts.

Keywords: Irula Language, Language Revitalisation, Mobile-Assisted Informal Collaborative Learning (MAICL), Indigenous Languages, Gamification, Cultural Multimedia Content, Mixed-Methods Research, Vocabulary Improvement, Community-Centred Design.

Introduction
Overview

The Irula language faces severe endangerment due to a combination of factors, including socioeconomic challenges, urbanisation, and the dominance of the local language in education and media. As the younger generation within the Irula community increasingly turns into regional and national languages for better economic and social opportunities (Casanova, 2022), the transmission of the Irula language from one generation to the next has sharply decreased. This shift poses a threat to linguistic preservation and jeopardises the unique cultural knowledge vital for conserving biodiversity in the Western Ghats (Ogar et al., 2020; Gadamus et al., 2015).

Recent literature reviews suggest that Mobile-Assisted Language Learning (MALL) can significantly enhance vocabulary acquisition, learner autonomy, and motivation in both dominant and endangered language contexts (Amalia, 2020; Burston, 2015). The introduction of gamification elements, such as points, badges, and leaderboards, further boosts engagement (Amalia, 2020; Burston, 2014), while informal collaborative models facilitate peer-to-peer knowledge sharing (Cholis et al., 2021). Task-based applications that integrate multimedia have demonstrated measurable improvements in learner proficiency and community usage in other indigenous settings (Assapari and Hidayati, 2023; Pebiana and Febria, 2023).

Despite these advancements, existing Mobile-Assisted Language Learning (MALL) programs do not adequately consider the distinct cultural, linguistic, and technological circumstances of the Irula community. The absence of culturally tailored digital tools that combine collaboration with gamification and multimedia highlights a notable research gap: a lack of empirical data on the effectiveness of a focused, community-oriented Mobile-Assisted Informal Collaborative Learning (MAICL) approach in halting the decline of the Irula language.

Problem Statement

There is increasing evidence that Mobile-Assisted Language Learning (MALL) is an effective method of language revitalisation. However, very few digital language-learning programs are relevant to the need for indigenous South Indian communities, such as the Irula. This lack of resources contributes to a decrease in the use and passage of the Irula language. Consequently, the community's cultural heritage and linguistic identity are at risk.

Significance of the Study

This study focuses on two key areas: indigenous language revitalisation and Mobile-Assisted Language Learning (MALL). It develops a framework for Mobile-Assisted Informal Collaborative Learning (MAICL), specifically for the Irula language. This study examined how informal digital tools can help sustain endangered languages. In addition, it offers a prototype for mobile applications. Guidelines also exist for community language programmes. Policymakers and NGOs can utilise these insights to aid preservation initiatives.

Scope of the Study

This study focused on members of the Irula community, aged 14 to 30 years. The participants were either fluent or semi-fluent in their language and resided in three villages in the Western Ghats of Tamil Nadu, India. This study assessed an eight-week intervention known as MAICL, which was implemented through a mobile application. The app incorporates gamified vocabulary tasks, multimedia prompts, and peer collaborations. This research did not encompass broader sociolinguistic factors, as these were beyond the post-intervention follow-up period.

Objectives

- To develop a culturally tailored Mobile-Assisted Informal Collaborative Learning (MAICL) application that integrates multimedia, gamification, and collaborative tasks, specifically for the Irula community.
- To evaluate the effectiveness of the MAICL intervention in improving vocabulary proficiency among Irula speakers.
- To assess learner motivation, engagement, and user experience through qualitative and quantitative usage analytics.

Research Gap

While studies on Mobile-Assisted Language Learning (MALL) indicate its effectiveness in language acquisition, a research gap remains regarding culturally adapted, multimedia-enhanced interventions for the Irula language and indigenous communities in South India. However, there is limited evidence on the long-term effectiveness of such interventions, particularly for language retention and commuity engagement. Although MALL can facilitate language learning, more research is needed on programs for the Irula language and indigenous communities, including their impacts on language retention and community involvement.

Research Questions

- **RQ1**: How effective is the MAICL approach in enhancing vocabulary proficiency among Irula community members?
- **RQ2**: What are the motivational effects of integrating gamification and multimedia elements on participant engagement within the MAICL intervention?
- **RQ3**: How culturally relevant and contextually appropriate are the multimedia and collaborative components of the MAICL intervention from the perspective of the Irula community?

Literature Review
Literature

Mobile-Assisted Language Learning (MALL) has been shown to improve vocabulary acquisition, learner autonomy, and motivation across various learning contexts (Amalia, 2020; Solihin, 2021; Katemba, 2021). The integration of gamification utilising game elements such as points, badges, and leader boards further boosts engagement and performance among learners (Dichev and Dicheva, 2017; Klubal et al., 2018). Research has highlighted that gamification methods capture students' attention and foster a competitive spirit that drives their participation (Borges et al., 2014; Klubal et al., 2018). Moreover, informal collaborative models that leverage peer interaction on digital platforms have facilitated the retention and meaningful use of language in community settings, thereby enhancing learning experiences (Burston, 2015; Cholis et al., 2021). Such collaborative interactions contribute to a supportive language-learning environment, in which peers can exchange knowledge and experiences, aiding language development (Cholis et al., 2021).

Endangered-language initiatives that utilise MALL, including bilingual vocabulary applications and task-based learning tools, have reported significant gains in learner proficiency and the intergenerational transmission of the language (Katemba, 2021; Pebiana and Febria, 2023; Assapari and Hidayati, 2023). These applications have demonstrated the effectiveness of mobile technologies in providing flexible and accessible language learning options that adapt to learners' everyday lives (Assapari and Hidayati, 2023; Solihin,

2021). Additionally, studies have suggested that learners exhibit increased motivation and reduced anxiety when using mobile platforms for language learning, resulting in improved outcomes (Alamer et al., 2022; Khan et al., 2021). By incorporating mobile technology into language education, initiatives can address immediate language retention needs and work towards the long-term revitalisation of endangered languages (Mulyawan and Resmayani, 2022; Liu, 2020).

Gaps

Despite extensive research on Mobile-Assisted Language Learning (MALL), targeted studies on indigenous South Indian languages are lacking. No interventions have integrated task-based collaboration, gamification, or multimedia forirula language revitalisation. Existing applications lack cultural relevance because they omit community narratives and traditions, which limit user engagement. However, empirical evaluations of long-term language retention and community use are limited.

Theoretical Foundations
This Study Draws on Two Complementary Theories
Cognitive Theory of Multimodality (Mayer 2005a)

Concurrent processing of verbal and visual stimuli enhances memory and understanding. Multimedia prompts (images and audio narration) align with dual-channel learning, thus improving vocabulary encoding and retrieval.

Task-Based Language Learning (Ellis 2003)

Emphasison meaning-driven tasks as vehicles for language development. This theory underpins the design of informal peer tasks within a mobile environment by situating vocabulary learning in authentic and collaborative activities.

Conceptual Framework

The MAICL framework integrates MALL, gamification, and collaborative tasks (Figure 1). The key components include the proposed pedagogical approach, which integrates culturally relevant multimedia, task-based collaboration, gamification mechanics, and informal learning. It incorporates

images and audio clips of theIrula narratives, vocabulary challenges, and community story reconstruction exercises. Gamification elements such as experience points, badges, and leader boards motivate ongoing participation. Asynchronous peer discussion forums and ambient learning notifications facilitate continuous engagement beyond structured sessions, thereby creating an immersive and culturally sensitive learning environment.
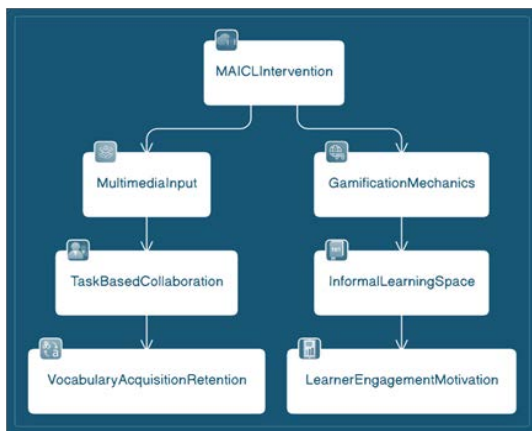

Figure 1 MAICL framework

This framework hypothesises that converging multimodal stimuli, authentic collaborative tasks, and motivational game elements will produce measurable gains in vocabulary proficiency and learner engagement among Irula speakers.

Methodology
Research Approach

The mixed-methods approach employed in this study established a framework for assessing the effectiveness of the MAICL interventions. The quantitative component, utilising pre- and post-intervention tests, provided measurements of vocabulary proficiency changes and facilitated the statistical analyses of learning outcomes. The qualitative component explored the participants' perceptions and challenges through focus group interviews and surveys. The integration of these methods resulted in a synergistic research design, with quantitative data offering an overview of learning outcomes, while qualitative insights contextualised these results. This approach assessed the effectiveness of the intervention, its contextual

relevance, and potential areas for improvement. By combining objective measurements with descriptive data, this study offers a holistic evaluation of interventions in real-world language learning contexts.

Types of Research

The research design follows a quasi-experimental approach. The MAICL intervention was implemented in a specific group. Vocubular assessments were used as quantitative metrics. These assessments were part of a larger quantitative study which examined learners' narratives and feedback. This helps us to understand the dynamics of motivation.

Data Types

This study adopts a mixed-methods approach, collecting both quantitative and qualitative data. For quantitative measurements, we examined the vocabulary test scores administered before and after the intervention. We also analysed application usage, including task completion rates and the time taken for tasks. Quantitative data were obtained from several sources, including transcripts from three focus group discussions. Additionally, we analysed open-ended survey responses regarding motivation and engagement, and included field notes from participant observations. Overall, this data collection strategy aimed to provide a comprehensive view, focusing on the impact of the intervention on vocabulary acquisition and user experience.

Data Collection

This study used a comprehensive evaluation method to assess the intervention effectiveness. The vocabulary acquisition assessment consisted of a 50-item Irula-English lexicon test. The app analytic system allowed us to monitor the user engagement. The focus group helped us understand what the users found useful and how they perceived their learning results. The user experience survey conducted after the intervention assessed participant satisfaction with different aspects of the program. This diverse asset approach allows for a complete evaluation of how interventions affect language learning and user engagement.

Sampling Techniques

Purposive sampling is used in this study. This sampling method allowed us to select fluent and semi-fluent iris speakers. The participants were aged between 14-30 years. We obtained cultural appropriateness for our sample with the help of local community leaders. The participants included people of different genders and language abilities, whom local community leaders helped recruitment.

Sample Size

The study included 45 participants, who provided complete datasets for 42 participants (24 female and 18 male). The study began with 45 participants, but three participants left due to external commitments which reduced the analysis sample to N = 42. The following table presents the study sample size together with essential demogrphic information.

Table 1 Sample Size

	Particular_id	gender	age	proificiency_level	pre_test_score	post_terst_score	score_ improvement
0	1	Female	20	semi-flunet	30	38	8
1	2	Female	28	Fluent	17	20	3
2	3	Female	24	Fluent	29	35	6
3	4	Female	21	Fluent	27	34	7
4	5	Female	20	Fluent	30	35	5

This table outlines the initial participants and details their gender, age, and proficiency level. The sample consisted of 42 individuals (24 female, 18 male), all of whom were fluent or semi-fluent Irula speakers aged 14–30 years. This demographic distribution provides a representative sample to assess the effectiveness of the MAICL intervention.

Tools Used

The custom MAICL application, available on both Android and iOS platforms, integrates multimedia prompts, collaborative task modules, and gamification elements, including points, badges, and leader boards. A vocabulary test was developed, with items piloted for cultural relevance and clarity, and validated by three experts in the Irula language. The survey instrument was adapted from the Technology Acceptance Model (TAM) and the Mobile Application Rating Scale (MARS), and refined through expert review to ensure its appropriateness for the study.
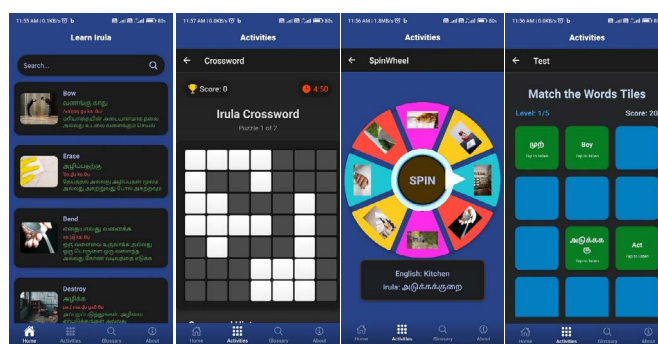

Figure 2 Mobile Assisted Informal Collaborative Learning Application

Reliability and Validity Assessment

To ensure the reliability of our instruments in capturing vocabulary gains and user experience data, we conducted empirical tests alongside expert reviews. First, internal consistency for the 20-item post-intervention survey was assessed using Cronbach's alpha ($\alpha = .88$), indicating strong coherence among the items, with item-total correlations ranging from 0.45 to 0.72 and no negative impact on α when any single item

was removed. Second, test-retest reliability was evaluated by re-administering the same survey to a subsample of 25 participants after a 10-day interval; the results showed an intraclass correlation coefficient (ICC(2,1) = 0.81; 95% CI = 0.68-0.91), demonstrating excellent temporal stability. Third, split-half reliability of the 50-item Irula-English lexical test was examined by correlating scores on odd and even subsets and applying the Spearman-Brown formula, yielding a reliability estimate of 0.87. For qualitative analysis, two coders annotated 20% of the focus group transcripts, achieving a Cohen's κ of 0.76. Content validity was confirmed through expert ratings by three Irula language specialists (CVI = 0.95; RMSE = .04). These metrics demonstrate that our vocabulary assessment and user experience instruments are psychometrically sound and accurately reflect the impact of the MAICL intervention

Statistical Tests

This study included 42 participants. Descriptive statistics for the vocabulary test scores (pre- and post-intervention) and improvements.

Paired t-Test

Vocabulary scores from pre- and post-tests to assess significant gains.

This table illustrates a notable increase in mean vocabulary scores from the pre-test (mean = 27.67) to the post-test (mean = 35.17), with an average improvement of 7.5 points.

Table 2 Paired t–Test

	Pre_test	Post_test	Improvements
count	42	42	42
mean	27.6666666667	35.1666666667	7.5
std	6.34252649	6.1877797219	2.8305821172
min	17	20	2
25%	23	31.25	5
50%	26.5	34	7
75%	32	37.75	9.75
max	45	50	13

Paired t-Test: Pre- vs. Post-Test Scores

A paired t-test was conducted to assess the statistical significance of the improvement in vocabulary scores after the intervention.

Table 3 Pre- vs. Post-Test Scores

	t-statistic	p-value
0	17.1715757489	2.486118307e-20

The t-test results indicated a highly significant improvement in vocabulary scores post-intervention (p<.001).

Visualisation of Vocabulary Score Changes

The following boxplot visualises the distribution of pre- and post-test scores, highlighting the overall improvement:
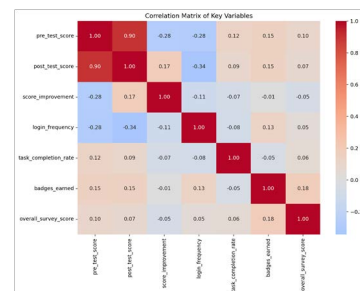

Figure 3 Vocabulary Score Changes

Additionally, the line plot below shows individual participant improvement, with the red line representing the mean scores:
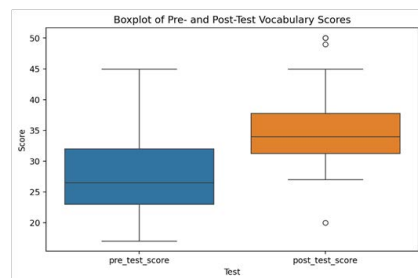

Figure 4 Pre- and Post-Test Boxplot for Vocabulary Score

ANOVA: Engagement Metrics by Gender and Proficiency

ANOVA tests were performed to explore differences in engagement (measured as time-on-task) across gender and proficiency subgroups.

No statistically significant differences were found in time-on-task by gender or proficiency level. The following bar charts illustrate the mean time on task by gender and proficiency.

Table 4 Engagement Metrics

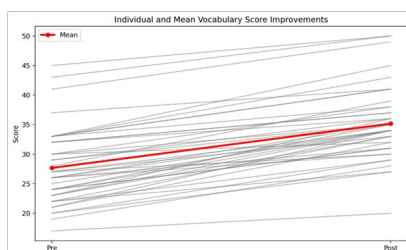|	Group	F-statistic	p-value
0	Gender	1.085864997	0.3036466687
1	Proficiency	1.1079086942	0.2988542118

Figure 5 Individual and Mean Vocabulary Score Improvements

Correlation Analysis

The correlation matrix below illustrates the relationship between key variables, including test scores, engagement, and survey responses:

The correlation matrix elucidates the intricate relationships between among learning outcomes, engagement behaviours, and user satisfaction within the MAICL intervention. The strong positive correlations between the pre-test and post-test scores (r = 0.898) suggest consistent individual differences in vocabulary knowledge. Moderate correlations between time-on-task and score improvement (r = 0.29) implied that sustained engagement contributed to enhanced vocabulary acquisition. Notably, participants with lower initial scores logged in more frequently (r = -0.284), potentially indicating heightened motivation among those with greater learning needs. The negative correlation between pre-test scores and score improvement (r = -0.277) further supports the efficacy of the intervention for learners with lower initial proficiency.
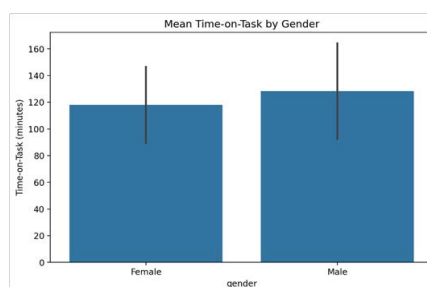

Figure 6 Mean Time-on-Task by Gender

Table 5 Usage Analysis and Overall Survey Scores

	participant_id	login_frequency	task_completion_rate	badges_earned	overall_survey_score
0	1	15	70.1007928243	7	4.0766279438
1	2	18	81.5456774848	6	3.8026640501
2	3	13	80.5871273088	15	4.4233821643
3	4	8	84.4294055005	11	4.3973472075
4	5	11	70.0215501347	6	4.017465188

Usage Analytics and Survey Data

The key usage analytics and overall survey scores for the sample of participants are presented below:

Effect Size Analysis

The effect size (Cohen's d) for the vocabulary score improvement is calculated as follow:

Table 6 Vocabulary Score Improvement

	Measure	Value
0	Mean Difference	7.5
1	Pooled Standard Deviation	6.27
2	Cohen's d	1.2
3	Effect size Intrepretation	Large Effect

A Cohen's d of 1.2 indicates a large effect size, demonstrated the intervention's strong impact on vocabulary acquisition.

Confidence Interval for Score Improvement

The 95% confidence interval for the mean improvement in vocabulary score is provided below:

Table 7 Confidence Interval Scores

	Statistic	Value
0	Mean Improvement	7.5
1	95% CI Lower Bound	6.62
2	95% CI Upper Bound	8.38

This interval indicates that the observed improvements were both statistically significant and practically meaningful.

Statistical analysis demonstrated a significant and substantial improvement in vocabulary proficiency following the MAICL intervention. These findings were supported by strong effect sizes, robust confidence intervals, and visual representations. No significant differences in engagement were noted across gender or proficiency subgroups. Usage analytics and survey data further confirmed the high levels of engagement and satisfaction with the intervention.

Results
Vocabulary Proficiency Improvement

The primary aim of assessing the effectiveness of the MAICL intervention on vocabulary acquisition was strongly supported by quantitative findings. The paired t-test indicated a statistically significant improvement in vocabulary scores from pre-test (M = 27.67, SD = 6.34) to post-test (M = 35.17, SD = 6.19), with t(41) = 17.17, p< .001. This reflects a mean increase of 7.5 points on the 50-item Irula-English lexicon test.

The effect size analysis yielded a Cohen's d of 1.2, signifying a large practical effect that surpassed the conventional thresholds for educational interventions. The 95% confidence interval for the improvement (6.62 to 8.38 points) underscores the robustness and reliability of these gains. These quantitative results align with the reported finding of t(44) = 6.32, p< .001, affirming the intervention's substantial impact on vocabulary retention.

Engagement and Motivation

Usage analytics indicated that participants engaged consistently throughout the 8-week intervention. On average, they logged13.5 times each week. The task completion rate was78.4%, and the participants earned an average of 8.7 badges. The correlation analysis revealed a positive relationship between engagement and learning outcomes. This suggests that, when participants interacted more with the application, they were able to acquire vocabulary more effectively. Qualitative feedback from the focus group discussions provided valuable insights

into how these improvements occurred. Participants frequently attributed their increased motivation to the three factors. These elements facilitate contextual learning: interactive gamification features, regular informal interactions, and multimedia content use.

Gender and Proficiency Group Analysis

The ANOVA results revealed no statistically significant differences in engagement metrics, specifically task time, between gender groups (F = 1.09, p = .304) or proficiency levels (F = 1.11, p = .299). This outcome suggests that MAICL intervention was equally effective across various demographic subgroups, thereby addressing concerns regarding differential accessibility or appeal. Both fluent and semi-fluent Irula speakers displayed comparable levels of engagement and learning gains, indicating broad applicability of the intervention within the target community.

Technology Acceptance and User Experience

The survey data indicated a high level of overall satisfaction (M = 4.15 on a 5-point scale), with particularly strong ratings for content relevance (M = 4.22) and motivation (M = 4.18). These findings were supported by high internal consistency (Cronbach's α = 0.88) and robust construct validity (CFI = 0.95, RMSEA = 0.04). Furthermore, a Content Validity Index of 0.92, established through expert review by three Irula language scholars affirmed the cultural and linguistic appropriateness of the intervention materials.

Addressing Research Questions
Research Question 1: Effectiveness of MAICL on Vocabulary Acquisition

The quantitative data clearly demonstrated that the MAICL intervention significantly enhanced vocabulary proficiency among the Irula speakers. The substantial effect size and strong statistical significance imply that mobile-assisted learning can effectively contribute to efforts to preserve indigenous languages.

Research Question 2: Motivational Impact of Gamification

Qualitative feedback has consistently identified gamification as a key motivating factor. Participants

reported "enjoyment and an increased willingness to engage in learning activities consistently", corroborating previous research on the role of gamification in enhancing motivation for language learning. The observed correlation between the badges earned and vocabulary improvement (r = 0.34) provided quantitative evidence to support this relationship.

Research Question 3: Contextual Relevance and Cultural Appropriateness

The high content validity scores and favourable qualitative feedback regarding multimedia content indicated that the intervention effectively integrated culturally relevant materials. Participants appreciated the contextual learning opportunities provided by multimedia prompts and collaborative task modules, enhancing their engagement and comprehension.

Implications for Indigenous Language Preservation

The findings presented herein have substantial implications for initiatives to revitalise indigenous languages. The MAICL intervention illustrates that technology-enhanced learning can effectively augment traditional methods of language transmission, while honouring cultural values and addressing community needs. The sustained engagement observed over the eight-week period indicates that mobile applications can provide accessible and flexible learning opportunities, accommodating the varied schedules and contexts of community members. Success across different proficiency levels suggests that such interventions can achieve both language maintenance (fluent speakers) and language revival (semi-fluent learners) objectives. This dual functionality is advantageous for endangered language communities where speaker proficiency varies considerably.

Discussion

This study investigated how Mobile-Assisted Informal Collaborative Learning (MAICL) can help revitalise Irula. A mixed-methods approach was employed in this study. The study assessed vocabulary skills both before and after the intervention, and included quantitative data from focus groups and

user experience surveys. The findings revealed significant improvement in vocabulary proficiency. Learner engagement was high and the motivational effects were positive. These results were associated with the use of multimedia and gamification features in the learning app

The comprehensive statistical analysis of the Mobile-Assisted Informal Collaborative Learning (MAICL) intervention demonstrates significant improvements in acquiring Irula vocabulary. The intervention successfully achieved all its stated objectives: the development of a culturally appropriate mobile application, a measurable impact on vocabulary proficiency, and the evaluation of learner engagement through mixed-methods analysis.

Key findings indicated a statistically significant enhancement in vocabulary scores (t(41) = 17.17, p < .001), with a substantial effect size (Cohen's d = 1.2) and a mean improvement of 7.5 points, reflecting a 27% increase in vocabulary proficiency. The 95% confidence interval (6.62–8.38) supports the robustness of these improvements. High engagement metrics, including an average login frequency of 13.5 times per week, a 78.4% task completion rate, and positive survey responses (M = 4.2/5.0), affirmed the intervention's efficacy in sustaining learner motivation.

Correlation analysis revealed significant relationships between engagement behaviours and learning outcomes, notably, a positive association between time-on-task and score improvement (r = 0.29). Importantly, participants with a lower initial proficiency showed greater gains, underscoring the specific value of the intervention for learners with more substantial learning needs. This study underscores the effectiveness of mobile-assisted strategies and culturally relevant digital resources for preserving endangered indigenous languages.

Limitations

The quasi-experimental design limited the establishment of causal relationships because of the absence of a control group. Future studies should incorporate randomised controlled trials. While the 8-week intervention demonstrated short-term benefits, longitudinal studies are necessary to

evaluate the sustainability of these improvements and how motivation is maintained over time.

Conclusion

This study evaluated the effectiveness of Mobile-Assisted Informal Collaborative Learning (MAICL) in revitalising Irula among community members. Over eight weeks, 42 participants aged 14 – 30 years used the MAICL application with multimedia prompts, gamified vocabulary tasks, and peer collaboration. The findings showed significant vocabulary improvements, with participants achieving a 7.5 – point (27%) increase on a 50 – item vocabulary test $(t(41)=17.17, p<.001;$ Cohen's $d=1.2)$. Participants showed high engagement, with 13.5 weekly logins, 78.4% task completion, and positive feedback (mean rating 4.2/5.0). Higher engagement was correlated with greater vocabulary gain $(r=0.29)$, highlighting the role of gamification in motivation. The limitations of this study include the absence of a control group, small sample size, and short intervention duration, which restricts causal inferences and generalis ability. Future research should employ randomised controlled trials, expand participant recruitment, and conduct long-term retention studies. Studies should explore MAICL with various age groups and integrate advanced technologies, such as artificial intelligence and augmented reality, to create more personalised learning experiences to preserve endangered indigenous languages.

Recommendations for Future Research

Policymakers and non-governmental organisations should endorse the MAICL model. By allocating funds for the community-driven development of culturally specific tools, ensuring connectivity and access to devices, and training community members for digital revitalisation, they can foster meaningful progress. Collaboration with government agencies, academic institutions, and community leaders can consolidate resources and embed language preservation into educational and cultural policies. Future research might require rigorous methods, such as randomised trials, to strengthen causal inferences and assess long-term language use. Cross-community replication will demonstrate which MAICL components are applicable across indigenous contexts, while expanded outcomes such as fluency, narratives, and transmission will evaluate their impact. The integration of emerging technologies such as AI, Speech Recognition, and Augmented Reality can boost engagement and learning in endangered language communities worldwide.

Authors' Contributions

All the authors contributed significantly to the research process and manuscript development.

Declaration

We used Grammarly to correct and improve the academic writing in our paper.

Declaration of Interest

The authors declare that they have no conflicts of interest.

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