

Design, Implementation, and Performance Evaluation of a Digital Teaching-Learning Platform for Traditional Sanskrit Education

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Abstract: In this paper, digital technology into education systems has gained more and more emphasis in the process of making education more accessible and more effective. The present study aims to explore the degree of computer literacy and digital readiness among the learners of the Traditional Sanskrit Teaching System in Uttarakhand and to assess the effectiveness of Digital Teaching-Learning Platform (DTLP) as an aid to Sanskrit teaching-learning process. Online and offline survey was used to collect data from the school students, college students and university students and other Sanskrit learners. Data analysis was conducted using quantitative techniques (frequency and percentage techniques) to look at patterns of digital awareness, technological resources and learners' preferences. The results show that 76.5% of the school students have incomplete computer know-how information, and 70.5% of college and university students need more support of computer literacy. In addition, 69.4% of other Sanskrit learners indicated that they needed an interactive online platform with some computer terminology. Based on the experimental results, it can be stated that in using the DTLP, the learning outcomes of the students are increasingly good, as evidenced by the percentage of 75.2% of university students, 71.2% of Sanskrit school students and 71.8% of other Sanskrit learners who experienced an improvement in their knowledge. The study therefore finds that if the digital infrastructure is provided and digital literacy training is provided, digital platform can play an important role in improving the traditional mode of teaching and learning in Sanskrit. The results underscore the need to combine the use of contemporary digital resources with traditional teaching methods to enhance learners' involvement and accessibility.

Keywords: Digital Teaching-Learning Platform, Role-Based Access Control, Natural Language Processing, Multilingual Query Processing, Knowledge Retrieval System, Performance Evaluation, Educational Technology Architecture.

1. Introduction

The education system of India has always been based on a traditional method that is known as Gurukula Dharma, where everything is taught orally, memorized, discipline and teacher-student interaction is very close. Despite having maintained the linguistic and philosophical purity of Sanskrit over the centuries it has been in use, it has its own set of problems in the contemporary educational system, such as availability of technology, lack of infrastructure, and computer literacy among learners and students.

The use of computer education and digital tools in a conventional education system has become a well-proven method for development of educational skills, accessibility and engagement of students in learning in recent years. The current research highlights the requirements for the development of a Digital Teaching-Learning Platform (DTLP) to meet the needs of Sanskrit learners in traditional way in Uttarakhand. The website wants to infuse traditional pedagogical methods in the framework of modern pedagogical tools and make it an interactive learning platform for students at schools, colleges, universities and other Sanskrit learning centers.

In the study, the fair amount of data collection has been carried out by administering the structured questionnaires to the traditional Sanskrit students, teachers, and learners of Uttarakhand to evaluate computer literacy, the needs of digital learning, and the challenges faced by them in the adoption of technology.



The study showed that a computer based platform, that incorporates ICT in learning solutions is needed, because many of the students in school, college, university and other learning institutions were not having the necessary computer skills.

The findings of this study led to the development of a computer curriculum with the help and guidance of Sanskrit education experts and computer education experts. To support the Digital Teaching and Learning Platform (DTLP), a multi-lingual database was created in English, Hindi and Sanskrit with features like user management, content management, separate dashboards for learners and teachers, and a robust feedback system, so that learners and teachers could interactively learn and create content. By combining traditional teaching methods with digital tools, the platform aims at addressing regional challenges, promote digital literacy, and bring in modern teaching methodologies into Sanskrit education.

In recent years, research has focused on the significance of Information and Communication Technology (ICT) in language learning and how it can enhance the learner motivation, flexibility in teaching and learning, and access to learning resources [4,14]. The use of digital learning environments with multimedia tools, the possibility of interacting with the content, and the application of Learning Management Systems (LMS) have proven effective in enhancing learner engagement, understanding, and retention [12,14]. In the field of Sanskrit education, the digitization of classical texts, use of natural language processing (NLP) for linguistic analysis, and the implementation of AI language models and automatic speech recognition (ASR) systems to assist with oral instruction are emphasized [1-3,17,19,20]. The digital integration of the educational system is reflected in the increasing number of institutional initiatives, in which universities like Sanskrit University and Uttarakhand Sanskrit University are including computer education and courses on ICT in their Sanskrit syllabuses, so as to enhance the digital skills of the students. [5-7] In addition, skill development programs are also held for Sanskrit students to promote computing skills [8]. The integration of technology with Indian Knowledge Systems (IKS) is being encouraged through policy initiatives such as the National Education Policy 2020 (NEP-2020) and plans for common digital Sanskrit libraries [18,21].

While there has been existing research on the use of ICT tools and digital resources in Sanskrit education, most of the research is focused on specific technologies or curricular initiatives, and not on digital teaching–learning platforms designed to work within traditional Sanskrit education systems [4,14,15]. The research on the integrated pedagogy oriented digital teaching learning platform has been limited in region Uttarakhand and it is necessary to have a region specific framework that is compatible with the traditional system of Sanskrit education [10, 18]. AI has additionally been used to make Sanskrit content and teaching easier to access [31].

To fill this lacuna, the present study recommends an integrated Digital teaching-learning platform for the traditional Sanskrit educational system with reference to Uttarakhand.

The overall goal of this research is to design and develop a scalable Digital Teaching-Learning Platform (DTLP) with Role Based Access Control (RBAC) and multilingual Natural Language Processing (NLP) based knowledge retrieval within a formally modelled computational framework.

This study has the following main contributions:

The study examines the extent of digital readiness and Computer literacy of learners in traditional Sanskrit teaching system in Uttarakhand.

- Digital Teaching–Learning Platform (DTLP) is designed and implemented for the interactive learning of Sanskrit with the help of digital resources.
- A formal model which represents the operational workflow of the DTLP system was developed using a computational model.
- The effectiveness of the proposed platform was experimented with the feedback of the students of the Sanskrit school and the university.

2. Material and Methods

2.1 Research Design

The current study adopted a Design based and descriptive research method to design and analyse a Digital Teaching-Learning Platform (DTLP) for Traditional Sanskrit Teaching System (TSTS). The methodology is a combination of system design methods and survey-based data collection and analysis in order to guarantee the technical possibility and educational relevance.

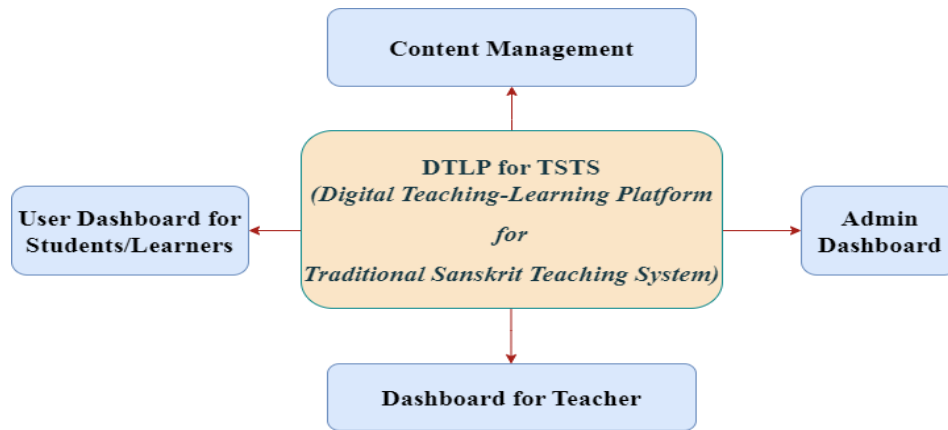


Figure 1. DTLP for TSTS

2.2 System Architecture

The system architecture depicts the structure and organization of the proposed Digital Teaching-Learning Platform (DTLP). A layered architecture model has been implemented, having the Presentation (User) Layer, Application Layer and Database Layer.

The presentation layer is a GUI of Sanskrit Students-Learners, Teachers and Administrators. Some of the services found in the Application Layer are dashboards, content management and user management.

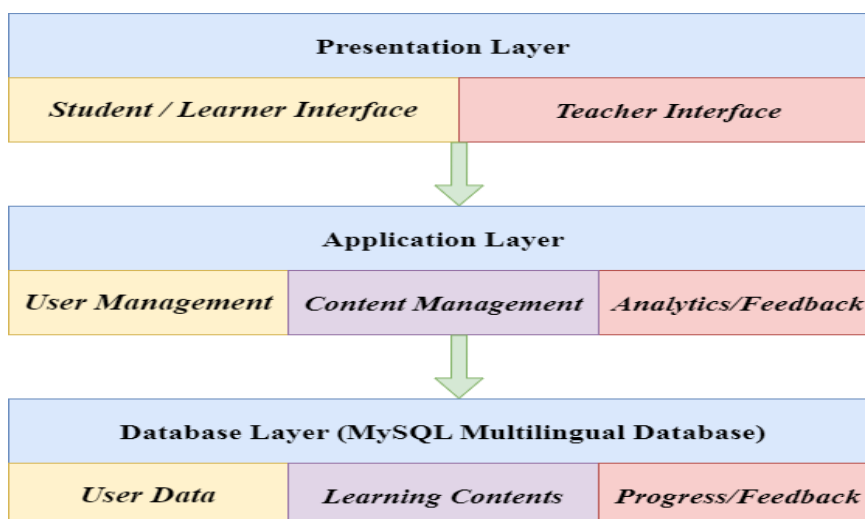


Figure 2. Layered System architecture of DTLP

DTLP's learning content, records, and assessment data are stored in the Database Layer. For this, a multi-lingual database in MySQL is being developed for data storage and retrieval which will allow Sanskrit students and learners to learn interactively and scalably from the database. The platform is validated by conducting experiments

with University students to provide the usability, feasibility and educational compatibility with the traditional Sanskrit institutions in Uttarakhand.

2.3 Algorithm Design

A role-based algorithm is developed to explain the operational workflow of DTLP. The algorithm starts with user authentication, then goes to role identification, and then to access the dashboard. The system allows the appropriate function depending on the user role: access to learning content, upload learning content, participation in assessment, etc. and system administration. The algorithm is designed to provide secure authentication and access control to the various functions of the system based on the role of the user.

Algorithm 1: Role-Based Operational Algorithm for DTLP

Input: User credentials $Uc = (\text{username}, \text{password})$

Output: Role-specific access to DTLP modules

- Step 1: Start
- Step 2: Receive login request from user.
- Step 3: Prompt the user to input credentials
(username, password)
- Step 4: Validate credentials using User_Database.
- Step 5: If authentication fails then
 - Display error message
 - Redirect to login interface
 - Repeat Step 3Else
 - Retrieve assigned role $e\ r \in R$
 - Generate a secure session identifier SID
- Step 6: Grant module access based on role r
 - If $r = \text{Student}$ then
 - Enable Learning, Search, Dictionary, Download,
Query modules.
 - Else if $r = \text{Teacher}$ then
 - Enable Content Upload, Assessment Creation,
Feedback modules
 - Else if $r = \text{Administrator}$ then
 - Enable User Management and Content
Management modules
- Step 7: While session SID is active
 - Process authorized actions.
 - Update database accordingly*
- Step 8: *Terminate session upon logout*

Step 9: End

2.4 Mathematical Model of DTLP

The Role-Based Operational Mechanism of DTLP is modeled formally as a structured access-control system. The model is formally defined as follows:

1. System Representation:

The Digital Teaching–Learning Platform (DTLP) is modeled as a structured access-control system represented as:

$$S = (U, R, M, D, A, F, Sess)$$

Where:

U = Set of users

R = Set of roles

M = Set of modules

D = Database

A = Authentication function

F = Role-to-module mapping function

Sess = Session management function

2. User Set:

$$U = \{u_1, u_2, \dots, \dots, u_n\}$$

Each user:

$$u_i = (username_i, password_i, role_i)$$

3. Role Set:

$$R = \{r_s, r_t, r_a\}$$

Where:

$$r_s = \text{Students}$$

$$r_t = \text{Teacher}$$

$$r_a = \text{Administrartor}$$

Role mapping function:

$$\text{Role}: U \rightarrow R$$

4. Module Set:

$$M = \{m_1, m_2, \dots, \dots, m_k\}$$

5. Authentication Function

$$A: U \times D \rightarrow \{0,1\}$$

$$A(u_i, D) = \begin{cases} 1, & \text{if credentials valid} \\ 0, & \text{otherwise} \end{cases}$$

If:

$$A(u_i, D) = 0 \Rightarrow \text{Access}(u_i) = \emptyset$$

If:

$$A(u_i, D) = 1$$

User proceeds to role-based authorization.

6. Role-Based Access Function:

$$F: R \rightarrow 2^M$$

Where 2^M represents the power set of modules.

7. Access control:

$$\text{Access}(u_i) = \begin{cases} F(\text{Role}(u_i)), & \text{if } A(u_i) = 1 \\ \emptyset, & \text{otherwise} \end{cases}$$

8. Session Model:

$$\text{Sess}(u_i) = \begin{cases} \text{Active}, & \text{if authenticated} \\ \text{Inactive}, & \text{after logout} \end{cases}$$

9. State Transition Model:

The system operates as a finite state machine (FSM):

$$FSM = (S_t, S_0, \delta)$$

Where:

$$S_t = \{\text{Login, Authenticated, Authorized, Logout}\}$$

$$S_0 = \{\text{Login}\}$$

$$\delta = \text{Transition function}$$

State transitions:

Login \rightarrow Authenticated (if A=1)

Login \rightarrow Login (if A=0)

Authenticated \rightarrow Authorized

Authorized \rightarrow Logout

2.5 Data Collection

A structured questionnaire was prepared to explore the learning challenges of the students of Traditional Sanskrit Teaching System (TSTS) concerning the digital teaching learning practices and for the design of an effective Digital Teaching-Learning Platform (DTLP) in the context of Uttarakhand.

The questionnaire formulated was aimed to gather required information on the computer literacy level of the learners, problems of evaluation of the digital tools for teaching of Sanskrit, and preference for interactive and multimedia based resources. The questionnaire was prepared with the study objective and was content validly checked by experts from Sanskrit and Computer Science field. Based on the suggestions of the experts forty questions were finalized for inclusion.

The survey included the students from the Sanskrit schools, colleges, universities and Sanskrit learners from Uttarakhand. The sample was selected on random basis and participation was voluntary. Online and Offline methods were used to gather data to assure a wider reach. The students, teachers and academic administrators of traditional institutions of Sanskrit education were queried.

3. Data Analysis

The collected data were analyzed quantitatively to gauge the computer literacy and digital readiness of the students of the Traditional Sanskrit Teaching System of Uttarakhand. The responses were screened for completeness and consistency and the data collected via both online and offline systems were merged into one data set for uniformity of analysis.

The descriptive nature of the study necessitated the use of statistical techniques such as frequency and percentage analysis to determine trends in digital awareness, technological resources, challenges in digital learning, and preference of the learners. The findings of the analysis of the data were grouped under the major thematic areas which correspond to the objectives of the study and to the proposed Digital Teaching-Learning Platform (DTLP). The analysis is based on the level of digital literacy, the need for computer support and the preference of learners in an interactive Digital Teaching-Learning Platform (DTLP).

3.1 School Students

There are a significant number of students in school level who are not computer literate. Figure 3, shows that 76.5% of school students reported that they lack a "foundational" digital readiness, as their knowledge of the computer is incomplete.

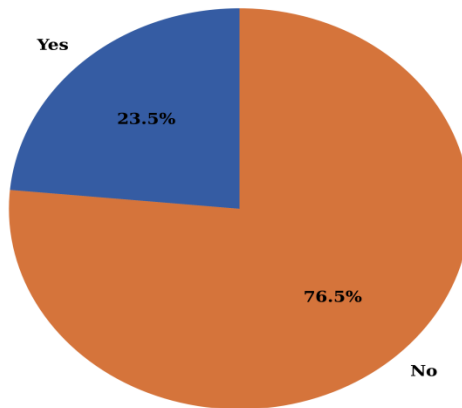


Figure 3. Computer Literacy level among Sanskrit school students

3.2 College and University Students

There are a large proportion of higher able pupils who need more help to benefit from the use of digital learning tools. As illustrated in Figure 4, 70.5% of the college and University students expressed the need for further support in computer literacy.

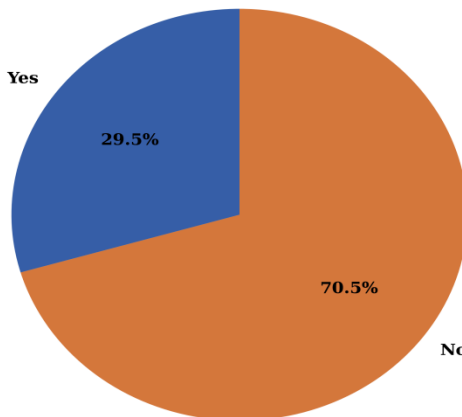


Figure 4. Computer Literacy Support Requirements among College and University Students

3.3 Other Sanskrit Learners

Most of the other Sanskrit learners said that they needed a digital platform that offered interactive learning and some basic computer terminology support. Figure 5, shows this trend where 69.4% of learners stated that this was a required trend. An overall summary of the results can be seen in Table 1, which presents digital literacy and platform requirements for all learner groups.

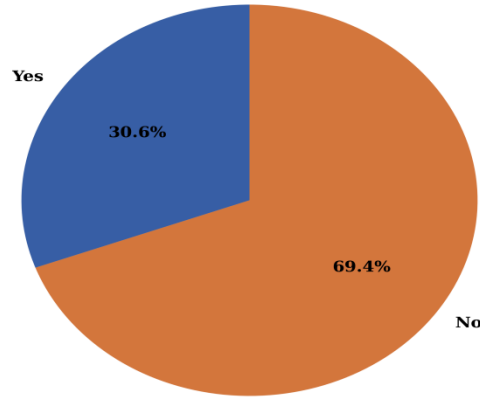


Figure 5. Computer Literacy Level among Other Sanskrit Learners

Table 1. Computer Literacy and Digital Support Requirements among Sanskrit Learners

Learner Category	Key Indicator Assessed	Percentage (%)	Interpretation
School Students	Lack of complete computer knowledge	76.5%	Indicates low digital literacy at the foundational level
College / University	Need for additional computer literacy support	70.5%	Shows moderate skills but requires guidance
Other Sanskrit Learners	Demand for interactive DTLP with basic computer terminology	69.4%	Highlights preference for interactive digital learning

4. Experimental Result

This study aims to assess the effectiveness of the proposed Digital Teaching-Learning Platform (DTLP) to assist the traditional Sanskrit teaching-learning process. A percentage analysis was used to analyse the responses obtained from the university students and Sanskrit school students for knowing about the perceptions of students about the usefulness of the platform in improving the teaching-learning process.

4.1 Perception of University Students

Analysis of the responses received from the university students shows a positive attitude towards using the Digital Teaching-Learning Platform in general. The DTLP was found to be useful for learning activities of the respondents as shown in the Figure 6; it was reported by approximately 75.2% whereas about 24.8% reported no significant change.

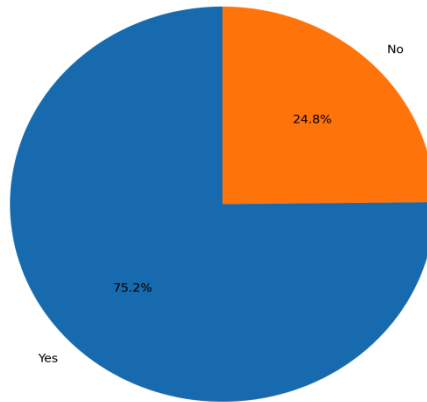


Figure 6. Knowledge Improvement Reported by University Students after Using DTLP

The students were reported to be very thankful for the flexibility and access to the digital platform. Students reported that the DTLP gave them access to study resources and digital texts, and provided multimedia explanations that were more convenient than those provided in the classroom alone. The platform also enabled the students a revisit to the learning materials when necessary. A minority of children are said to experience problems using the digital platform, however.

Others indicated connectivity and technical problems, as well as digital learning tools they did not know. These factors could affect the effectiveness of digital platforms across learning environments.

4.2 Perception of Sanskrit School Students

The feedback of the students from the Sanskrit school also showcases positive attitude towards the Digital Teaching-Learning Platform.

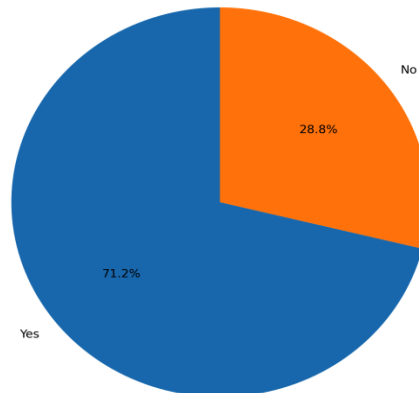


Figure 7. Knowledge Improvement Reported by Sanskrit School Students after Using DTLP

As shown in Figure 7, 71.2% of the students were positive about it and believed that the digital platform helped them understand the concepts in Sanskrit and access the learning material. However, 28.8% of the respondents said that they did not find the platform useful in their learning.

The positive responses indicate that digital learning tools can be of great help in the context of the traditional Sanskrit education. Students felt that the audio pronunciation guides, digital text and multimedia explanations helped them understand the Sanskrit grammar and pronunciation.

However, the percentage of negative responses reveals some challenges for using digital platforms in Sanskrit schools. The barriers facing these include the lack of digital devices in the classroom, inadequate infrastructure in some regions, and the general practice of traditional teaching methods (oral instruction and memorization).

4.3 Perception of Other Learners

The feedback from other learners of Sanskrit suggests a positive attitude towards the DTLP. As seen in Figure 8, 71.8% of the respondents have a positive perception with respect to the DTLP indicating that the majority find the DTLP useful, effective or beneficial for learning Sanskrit. While 28.2% do indicate a smaller number of people who may have concerns, problems or limited satisfaction with the platform.

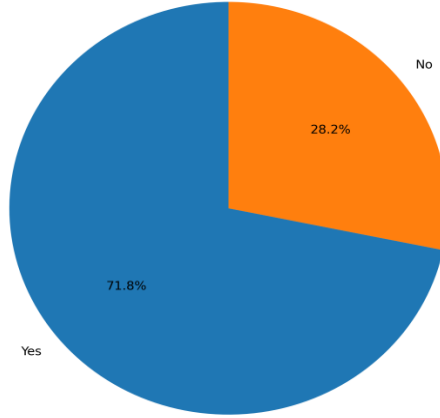


Figure 8. Knowledge Improvement Reported by other Sanskrit Learners after Using DTLP

4.4 Comparative Analysis

A comparison of the digital teaching–learning platform acceptance level for the university students, Sanskrit school students, and other Sanskrit students shows that there is no significant difference between the group of university students and the group of Sanskrit school students (75.2 % and 71.2 %) and between the group of Sanskrit school students and the other Sanskrit learners (71.2 % and 72.8 %). The difference could be explained by the higher level of exposure of university students to digital technologies and online learning environments. Table 2 and Figure 9 show that the DTLP is positively affecting learner knowledge and engagement.

Table 2. Learning Improvement after Using DTLP

Learner Category	Improved	Not Improved
University Students	75.2%	24.8%
Sanskrit School Students	71.2%	28.8%
Other Sanskrit Learners	71.8%	28.2%

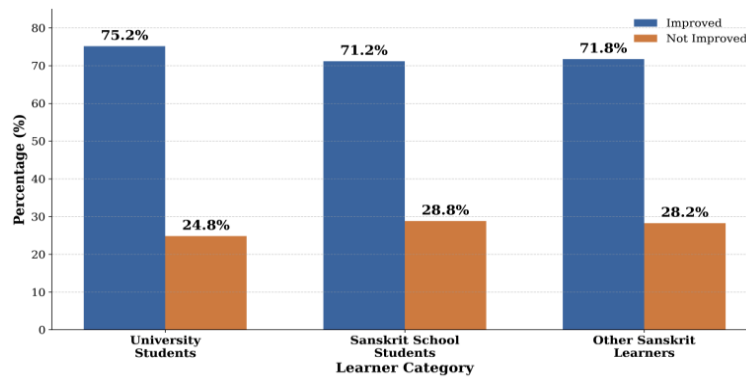


Figure 9. Knowledge Improvement Analysis among Learner Categories after Using DTLP

Overall, the findings indicate that DTP has a significant potential for making Sanskrit education more effective as it allows access to learning resources in a flexible way, and supports interactive learning experiences. The results also underscore the importance of enhancing technological structures and digital literacy for effective use of digital learning platforms in traditional education.

5. Discussion

The results of the present study have revealed the increased significance of introducing digital technologies in the Traditional Sanskrit Teaching System of Uttarakhand. The analysis also suggests that the learners had a positive attitude towards digital learning platforms, but they were not all equally prepared for digital learning in the various categories of learners.

The study also reveals that there is a low level of digital literacy in the school level Sanskrit students as 76.5% of them does not have complete knowledge of computers. This indicates that the digital platforms in Sanskrit schools should be backed by enhancing basic computer skills of learners. In the traditional Sanskrit education, it was taught orally, by memorizing, and the teacher-centered teaching method. While these pedagogical approaches have successfully maintained the continuity and sustainability of language and culture, limited access to digital learning tools among students in the school might limit their effective use of modern learning platforms.

According to the answers given by the students of the college and university, 70.5% of them need further computer literacy support to utilize the digital learning tools well. It indicates that people with a higher educational level seem to be familiar with digital technologies, but do not necessarily have the technical skills to make best use of digital learning environments. Thus, it can be concluded that the use of digital platforms for Sanskrit learners at higher education level may be improved by the use of structured digital training and orientation programs.

The study shows that it is highly required for the other Sanskrit learners for an Interactive Digital Teaching-Learning Platform (DTLP) wherein 69.4% of the respondents indicated their need for interactive facilities and basic computer terms. The study implies that the application of the interactive tools (such as: multimedia explanation, digital texts, pronunciation support) can improve the learner engagement and support the understanding of the Sanskrit grammar and phonetics.

The evaluation of the Digital Teaching-Learning Platform is also done on the experimental level, which proves its positive effect on the learning process. 75.2% of the participants in the University stated that they noted an improvement in their knowledge after using DTLP, thus indicating that the use of digital platforms offers opportunities for learning beyond the classroom. Students can access materials, multimedia explanations, and digital texts and learn at their own speed and review when needed.

Of the Sanskrit school students and 71.8% of other Sanskrit learners indicated that their understanding about Sanskrit has increased when using the DTLP. The audio pronunciation guide, the multimedia explanation and digital content were reported to be useful in grasping Sanskrit language concepts. The results suggest that the digital learning tools are useful in augmenting traditional Sanskrit teaching and learning and can play a significant role in making it accessible and engaging to learners.

The comparative analysis also shows that university students have slightly more acceptance of the DTLP (75.5%) than Sanskrit school students (71.2%) and other Sanskrit learners (71.8%). The difference could be explained by the fact that University students are more exposed to digital technologies and online learning systems. Therefore, there is a need for enhanced support for successful integration of a digital platform in Sanskrit schools, which can include digital infrastructure, teacher training, and providing basic computer education for students.

In summary, the findings indicate that the Digital Teaching-Learning Platform holds great promise for improving the effectiveness of Sanskrit education, such as offering greater flexibility in accessing learning resources and facilitating engaging learning experiences. To make best use of such platforms, however, digital literacy, infrastructure and training of users are critical challenges to be addressed.

The results highlight the importance of integrating conventional teaching methods with technology in Sanskrit education. It is essential to make learners and teachers digital ready in order to successfully implement technology-enabled teaching-learning systems in traditional Sanskrit education.

6. Conclusion

This research aimed to explore the computer literacy and digital readiness skills of learners in Traditional Sanskrit Teaching System of Uttarakhand and assessed the effectiveness of Digital Teaching-Learning Platform (DTLP) for Sanskrit teaching learning. The findings show that the computer knowledge of learners is not sufficient, especially at the school level, which affects their utilization of digital learning tools to the fullest. The results also demonstrate that many college and university students need extra computer literacy assistance to be able to interact effectively with digital platforms.

However, the experiences show that the Digital Teaching-Learning Platform positively affects the learning experience in Sanskrit. 71.8% of students at the other Sanskrit schools and 75.2% of the university students said they learned more about Sanskrit after using the platform while 71.2% of the Sanskrit school students experienced improvement. Among the university students, 75.2% experienced improvement in their understanding of Sanskrit after using the platform, while 71.8% of the students in other Sanskrit schools did so. The findings indicate that adopting digital technologies could enhance the conventional teaching and learning of the Sanskrit language by offering opportunities for self-paced learning, multimedia explanations, and access to learning resources that are flexible.

The study also identifies a number of challenges in the effective use of digital learning platforms, such as the lack of digital infrastructure, access to devices, and digital literacy of learners. The solutions to these challenges will be crucial in achieving successful implementation of TELE in traditional Sanskrit learning institutions.

Future study could include the incorporation of more sophisticated features like adaptive learning modules, online assessments, and collaborative tools. Furthermore, studies with more extensive and representative groups of learners are recommended to assess the long-term effects of digital platforms on language learning, student engagement and teaching effectiveness.

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