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SheSphere-An Integrated Digital Ecosystem for Women's Learning, Community Engagement, and Entrepreneurship

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ABSTRACT- Women often face challenges in accessing personalized learning resources, developing practical skills, and connecting with like-minded communities. These challenges can be addressed by integrating personalized learning, skill development, community engagement, and e-commerce into a single platform. SheSphere is an Integrated Digital Ecosystem for Women's Learning, Community Engagement and Entrepreneurship. Developed using the MERN stack, the platform incorporates a hybrid recommendation system combining K-Means clustering, Content-Based Filtering, Collaborative Filtering, and Time-Aware Recommendation to suggest relevant learning videos based on user's interests, behaviours, preferences and available time. In addition, the platform offers multiple language options, including English, Hindi and Kannada, a range of interest-based communities, a marketplace, journal, streak counter, gamification, notifications and a chatbot. The platform was tested by evaluating the functioning of the application, its modules, and the recommendation system and it was working as expected. Overall, the platform shows great potential in terms of providing an intelligent recommendation system and multiple functions for enhancing women's skills and knowledge.

KEYWORDS- Collaborative Filtering, K-Means Clustering, Personalized Recommendation, Time-Aware Recommendation

I. INTRODUCTION

Digital technologies offer a new opportunity for learning and skill development, community building and entrepreneurship. However, women, especially homemakers, encounter the challenge of finding flexible learning resources that suit their interest, time and involvement. Additionally, learning resources, community forums and entrepreneurial opportunities are scattered across different applications which creates a need for a single digital platform for women's learning and development.

Recommendation systems can offer a solution to the first challenge as they propose resources based on the user's interests and actions. Content-Based Filtering suggests similar resources according to the user's preferences, whereas Collaborative Filtering recommends resources based on similar user's behaviour. Moreover, K-Means can create user segments with similar attributes, and Time-Aware Recommendation can sort videos according to the learning time. Nonetheless, developing a hybrid recommendation system in a comprehensive digital platform according to the needs of women's learning and development remains as the primary challenge.

To address the above-mentioned requirements, this research introduces SheSphere Unified Intelligence Platform, a web application built using the MERN stack. The application's recommendation system utilizes K-Means clustering, Content-Based Filtering, Collaborative Filtering and Time-Aware techniques to recommend videos according to the users' interests, behaviors and time constraints. The platform was designed and built highlighting the importance of women's empowerment through multilingualism, community development, journaling, educational games, learning streaks, notifications and an AI chatbot.

The primary contributions of this research work include:

1. Development of SheSphere, an integrated platform that brings together learning, skill development, community interaction, and entrepreneurship in one place.
2. Grouping users based on selected attributes using the K-means clustering algorithm.
3. Implementation of hybrid recommendation system by combining Content-Based, Collaborative Filtering and Time-Aware strategies to recommend learning resources.
4. Integration of features such as multilingual engine, AI chatbot, journaling and streaks, community forums, educational games and notifications to support user's learning and engagement.
5. Evaluation of the implemented system and a proof-of-concept experiment with seven users to analyze user segments.

The rest of the paper is structured as follows: Section II provides an overview of literature review. Section III states the problem statement. Section IV highlight's objective of our platform whereas Section V describes the methodology and recommendation algorithms used in this study. Section

VI discuss the experimental results and analysis. Section VII outlines the future work and concludes the research.

II. LITERATURE REVIEW

Research on personalized e-learning has been explored considering different recommendation approaches to provide suitable learning resources to the user. Tarus, Niu, and Mustafa [1], reviewed knowledge-based recommendation approaches for e-learning and highlighted the importance of providing relevant learning resources based on the requirements of a learner. Drachsler, Hummel, and Koper [2] studied on the personal recommender system for the lifelong learning network, and discussed the requirements and techniques of providing personalized recommendations. These studies address the importance of personalization in digital learning environment.

The role of information and communication technologies in women empowerment has been studied. Srinivasaragavan, Sakthivel, and Prasanna Kumari [3] examined the ICT awareness and skill level of rural women, and highlighted the contribution of digital technologies for education, skill development, communication, and entrepreneurship. Amarjeet and Bhura [4] studied the importance of ICT in women empowerment and discussed the role of ICT in education, employment, entrepreneurship, and social interaction. These studies address the importance of using digital platforms for the improvement of women literacy and economic status.

Fidan [5] investigated the microlearning-supported flipped classrooms and examined their impact on learning performance, motivation, and engagement. Monib, Qazi, and Apong [6] provided a systematic review of micro learning and discussed their potential in improving learning outcomes through the implementation of flexible and manageable learning activities. These studies are relevant for SheSphere because the platform considers the available learning time of a user when recommending learning videos.

Gamification has been studied as a method to enhance learning engagement. Dichev and Dicheva [7] critically reviewed gamification in education and examined the application of game-based elements for educational engagement. Khaldi et al. [9] conducted a systematic literature review on gamification in higher education and found that elements such as points, badges, leaderboards, levels, and feedback are commonly used to improve learner engagement.

Machine learning techniques have been increasingly explored in recommendation system. Li and Wu [8] presented an enhanced version of K-Means clustering algorithm to overcome shortcomings of conventional K-Means algorithm such as sensitivity towards initial cluster centres and getting trapped in local minima. Liu [10] proposed a hybrid data-mining framework that combines DBSCAN, K-Means clustering and FP-Growth algorithm to improve data analysis. The study showed that combining clustering and association rule mining can improve clustering quality and the reliability of discovered patterns. Yassine, Mohamed, and Achhab [11] proposed intelligent recommender system based on unsupervised machine learning and demographic attributes, which demonstrated the potential of user clustering and demographic data in recommendation system.

Content-Based, Collaborative, and Hybrid recommendation approaches have received significant attention in e-learning research. Joy and Pillai [12] reviewed and classified content recommenders in e-learning environment and highlighted the use of content attributes for generating relevant recommendations. Khanal et al. [13] presented a systematic review of machine-learning-based recommendation systems for e-learning and discussed Content-Based, Collaborative and Hybrid recommendation approaches. Alabduljabbar, Alshareef, and Alshareef [14] reviewed Time-Aware Recommender Systems and emphasized the use of temporal information in recommendation process. de Campos et al. [15] investigated the combination of Content-Based and Collaborative recommendations through hybrid approach and demonstrated the potential of combining multiple recommendation approaches.

Based on these studies, the existing research provides important background for personalized learning, user clustering, content-based recommendation, collaborative filtering, time-aware recommendation, gamification and women empowerment through ICT. SheSphere builds on these concepts by integrating K-Means Clustering, Content-Based Filtering, Collaborative Filtering, Time-Aware Recommendation and Hybrid Recommendation in a single platform. In addition to personalized learning, the proposed platform also combines interest-based communities, personal development features, AI-powered chatbot, and marketplace, providing an integrated environment for learning, social interaction, skill development, and economic opportunities.

III. PROBLEM STATEMENT

Many women, particularly homemakers, face limitations in accessing personalized learning opportunities, developing new skills, connecting to like-minded people and finding suitable platforms to showcase or monetize their skills. Existing applications focus on individual needs that include education, social interaction, journaling or online selling and requiring the user to rely on multiple platforms for different activities. In addition, generic learning platforms may not consider factors such as a user's interests, learning behaviour, available free time and preferred language when providing content recommendations. This highlights the need for an integrated and personalized digital platform that can unite learning, community interaction, personal development and economic opportunities in a single environment. The platform should provide personalized learning content considering user interests, learning activities, interaction patterns and available learning time. It should also provide interest-based communities, learning progress, journaling, skill-based activities and opportunities for the user to showcase and utilize their skills.

To address these challenges, SheSphere Platform is developed as a web-based platform that combines personalized recommendations, community engagement, AI-powered chatbot, journaling, games and marketplace. The platform also provides multiple languages.

IV. OBJECTIVES

The main objective of SheSphere Unified Intelligence Platform is to develop an integrated digital platform that supports women in learning, personal growth, skill development, community participation and economic

activities through personalized and intelligent features. The specific objectives are as follows:

1. To develop an integrated platform that supports women's learning, personal growth and skill development.
2. To implement intelligent recommendation techniques such as K-Means Clustering, Content-Based Filtering and Collaborative Filtering.
3. To allow users to connect with each other, form communities based on interests, post content and share messages.
4. To offer journaling, streaks, games and personal growth tools, as well as an AI chatbot.
5. To create a marketplace where users can display and sell items and process orders.

V. METHODOLOGY

SheSphere platform initially collects data from user's profiles, learning activities and interactions. Using the K-Means clustering algorithm users are classified by similar attributes. Recommendations can be made based on the users' profile using Content-Based Filtering, Collaborative Filtering and Time-Aware Recommendation. These take into account the attributes of learning content, user activity, recommendations from similar users and how much time they have to learn.

These recommendations are put together to create a hybrid solution. The recommendations are then shown on the dashboard which also contains other features such as communities, marketplace, journaling, games, learning streaks, notifications, multi-language support and an AI chatbot.

A. System Architecture

Frontend Architecture (Presentation Layer)-

- **Framework**: React 18 SPA built using Vite.
- **Styling and UI**: Tailwind CSS with custom responsive design tokens and dynamic theme context.
- **Localization**: i18next for seamless multi-language translation and accessibility.
- **Routing**: react-router-dom declarative client-side SPA routing.

Backend Architecture (Application Layer)-

- **Runtime**: Node.js (Asynchronous, Event-driven I/O model).
- **Framework**: Express.js REST API Server.
- **Database Interface**: Mongoose ODM (Object Data Modeling).
- **Authentication**: JSON Web Tokens (JWT) + Bcrypt password hashing.

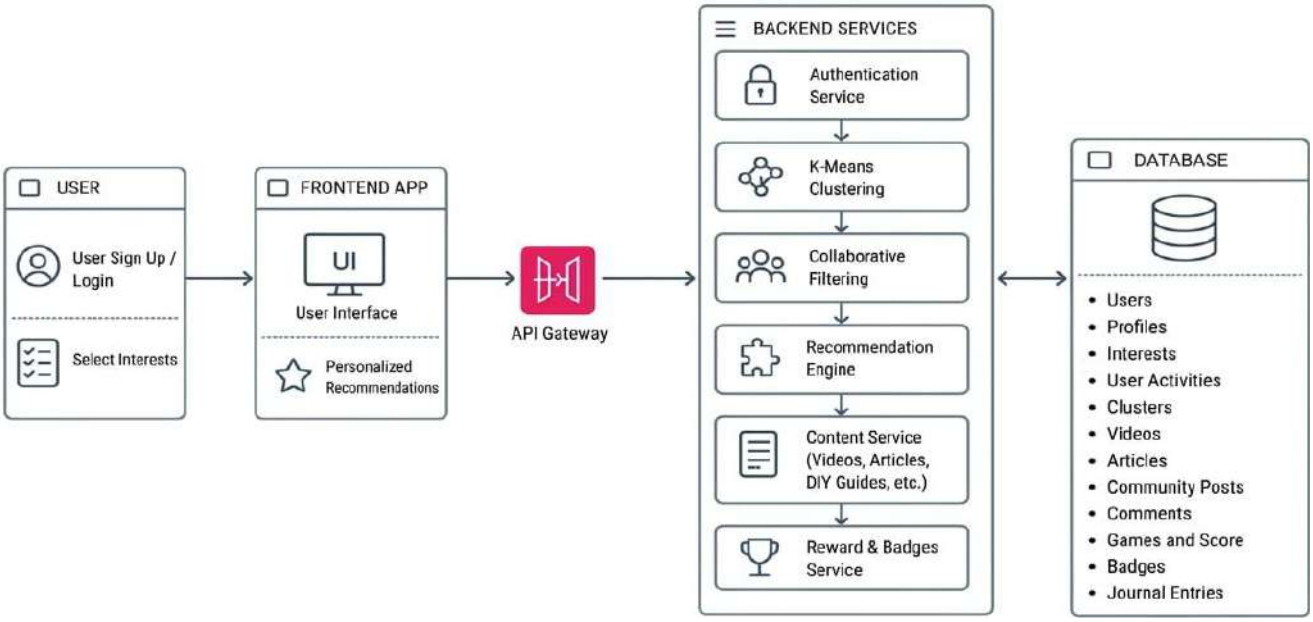


Figure 1: System Architecture

The System Architecture of the SheSphere Platform is shown in Figure 1. This allows the user to interact with the frontend. They can register and login to the platform and choose personal interests. The frontend connects to the backend via the API Gateway. The Authentication Service checks user details before allowing access to the platform. The K-Means Clustering algorithm groups the users by similar interests and behaviours. The backend uses the Collaborative Filtering and Recommendation Engine to create personalised content. This will be provided by the Content Service which contains videos, articles and guides. The Reward and Badges Service encourages user participation by providing badges for achievement. All user data, profiles, interests, activities, clusters, content, community posts, comments, scores, badges and journal entries are contained in a central database. This allows the platform to provide a personalisable service that is constantly being updated.

B. Algorithm

Algorithm 1: K-Means Based User Clustering

K-Means clustering groups users based on their profile and learning activities. An 18-dimensional feature vector is created using user interest, age, education, free time, language and engagement data. The clusters are generated using K-Means initialization and Euclidean distance.

Input: Active users U

Output: Cluster assignment for each user

1. Create an 18-dimensional feature vector for each user.
2. Normalize the user feature vectors.
3. Select the optimal Kusing WCSS.
4. Initialize centroids using K-Means++.
5. Repeat:
   Assign each user to the nearest centroid using Euclidean distance.
6. Recalculate the cluster centroids.
7. Until convergence or the maximum number of iterations is reached.
8. Store the cluster assignment for each user.

Algorithm 2: Content-Based Filtering

Content-Based Filtering recommends videos according to the user's selected interest and learning history. Category, subcategory and tag information are compared with the user's preferences. A weighted content score is calculated and the candidate videos are ranked accordingly to score.

Input: User interest C, watched metadata, candidate videos V
Output: Ranked content recommendations
1. **for** each video v in V **do**
2. Calculate category match score
3. Calculate subcategory match score
4. Calculate tag overlap score
5. $S_{CB} \leftarrow (total\ score)$
6. **end for**
7. Sort videos by S_{CB} in descending order
8. **return** ranked videos

Algorithm 3: Collaborative Filtering

Collaborative Filtering uses user interaction data such as video progress, completion and likes to identify users with similar learning interests. Cosine similarity is calculated between users and additional priority is given to users belonging to the same K-Means cluster. The interaction patterns of similar users are then used to calculate recommendation scores for candidate videos.

Input: Target user u, interaction matrix R
Output: Collaborative recommendation score
1. Calculate interaction scores from watch history and likes
2. **for** each other user u' **do**
3. Calculate Cosine similarity between $u$and u'
4. **if** u and u' belong to the same cluster **then**
5. Apply cluster similarity boost.
6. **end if**
7. **end for**
8. Calculate weighted predicted score for candidate videos
9. **return** collaborative scores

Algorithm 4: Time-Aware Recommendation

Time-Aware Recommendation takes the user's available daily learning time when selecting videos. The duration of each video is compared with the user's available time. Videos that fit the available time will get higher compatibility scores, while longer videos have a time penalty.

Input: Video duration D, user free time T
Output: Time compatibility score S_{Time}
1. Convert Tinto seconds
2. **if** $D \leq T$ **then**
3. Calculate compatibility score based on $\frac{D}{T}$
4. **else**
5. Apply overtime penalty
6. **end if**
7. Limit $S_{Time}$to the range [1]
8. **return** S_{Time}

Algorithm 5: Hybrid Recommendation

The Hybrid Recommendation algorithm combines Content-Based, Collaborative and Time-Aware recommendation score**s** to generate personalized learning recommendations. Collaborative information has higher weight when sufficient interaction data is available. For cold-start users, where collaborative information is unavailable, Content-Based and Time-Aware scores are used to generate recommendations. Completed videos are removed before the final ranking and the remaining videos are sorted according to their hybrid scores.

Input: Target user u, candidate videos V
Output: Ranked recommendations
1. Generate Content-Based score S_{CB}.
2. Generate Collaborative score S_{CF}.
3. Generate Time-Aware score S_{Time}.
4. **if** $S_{CF} > 0$**then**
5. $S_{Hybrid} \leftarrow 0.30S_{CB} + 0.45S_{CF} + 0.25S_{Time}$
6. **else**
7. $S_{Hybrid} \leftarrow 0.50S_{CB} + 0.50S_{Time}$
8. **end if**
9. Remove completed videos.
10. Sort videos by S_{Hybrid}in descending order.
11. **return** top recommendations.

C. System Workflow / Flowchart

In the next page Figure 2 shows the Flowchart of SheSphere Platform.

1. **Start & Landing Page** – This page provides an introduction to SheSphere and a login/signup option.
2. **Login / Signup** – Users can create an account or login to their account.
3. **Profile Setup** – The user has to enter basic details such as free time, education, language and age.
4. **Select Interest** – Users can select area of interest.
5. **Save to Database** – All the profile, interest and activity information will be saved to the MongoDB.
6. **Dashboard** – It provides access to Learning, Community and also Marketplace.
7. **Learning & Progress** – Access to personalized content and track user's learning progress.
8. **Community** – User can create their own posts and comment, share information.
9. **Marketplace** – Users can upload, view and manage products.
10. **Progress & Streak** – Track user's progress and learning streak based on your activity.
11. **End** – The system records the user's activities and provides a continuous personalized experience.

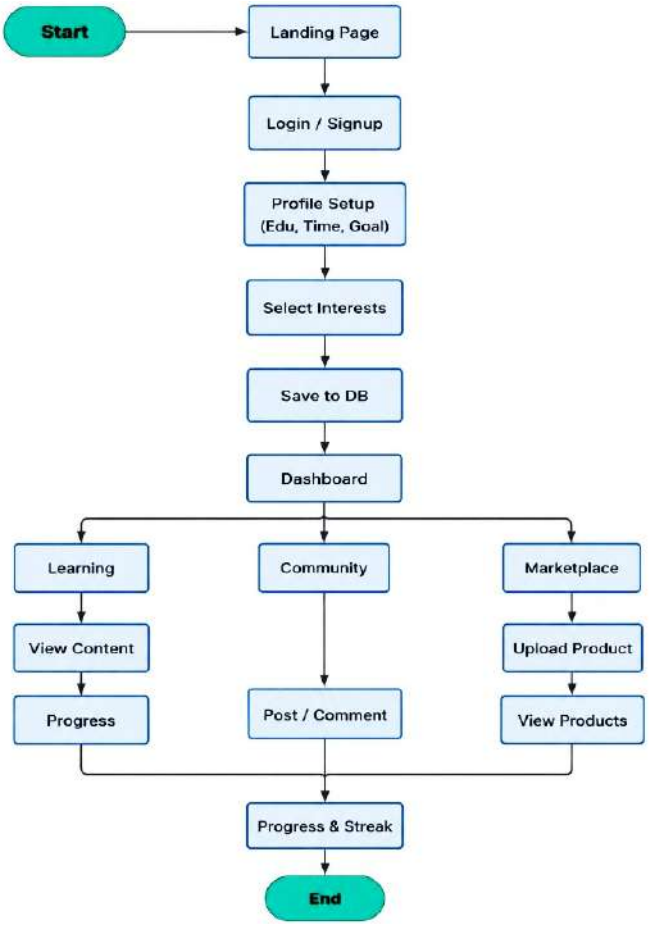


Figure 2: Flowchart of SheSphere Platform

VI. RESULTS AND DISCUSSION

The developed SheSphere Platform brings learning, community interaction, personal growth, marketplace services and AI features together in a single web application. The platform includes authentication, profile creation, interest selection, personalized dashboards, community interaction, a marketplace, journaling, games, learning streaks and an AI chatbot.

The recommendation system combines K-Means Clustering, Content-Based Filtering, Collaborative Filtering and Time-Aware Recommendation to suggest learning materials based on user's interests, profiles, learning behaviour and available time. These techniques work together through a hybrid recommendation approach to provide more relevant learning suggestions. Functional testing demonstrates that the implemented features worked properly.

Overall, the results shows the potential of SheSphere to provide personalized learning within an integrated platform. However, further evaluation with more active users is needed to assess recommendation effectiveness, particularly the accuracy of clustering and the performance of Collaborative Filtering.

A. Result Analysis of K-Means Cluster

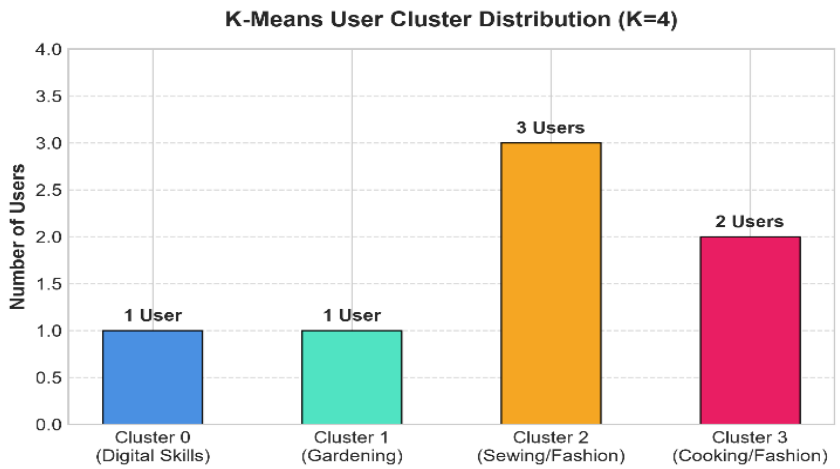


Figure 3: K-Means Cluster results

Besides, 1 user in Cluster 1 has an interest in Digital Skills. Thus, the designed K-Means model could be successfully applied to unite users on the basis of their interests and promote personalized learning recommendations.

The evaluation results for different cluster configurations, including WCSS, mean silhouette scores, cluster size distributions, and assessment outcomes, are showed in Table 1.

Table 1: K-Means Clustering Evaluation Results

Cluster Count (*K*)	WCSS	Mean Silhouette Score	Cluster Size Distribution (N=7)	Evaluation Assessment
K=2	2.5029	0.4633	Cluster 0: 6 users, Cluster 1: 1 user	High cohesion, but over-aggregates
K=3	1.8315	0.4079	Cluster 0: 5 users, Cluster 1: 1user, Clus ter 2: 1 user	Moderate separation
K=4	1.2291	0.3804	Cluster 0: 1user, Clus ter 1: 1 user, Cluster 2: 3 users, Cluster 3: 2 users	Optimal category segregation matching platform interests

B. Graphical Representation of Time Compatibility

The Time-Aware Recommendation algorithm considers the user's available daily learning time and the duration of each video. Users can select 15, 30, 45 minutes, or 1 hour as their available time. Videos that fit within this time receive higher compatibility scores, while longer videos receive a penalty. By evaluation, 136 out of 140 recommendations the available time, achieving a time compatibility rate of 97.14% as shown in the Figure 4.

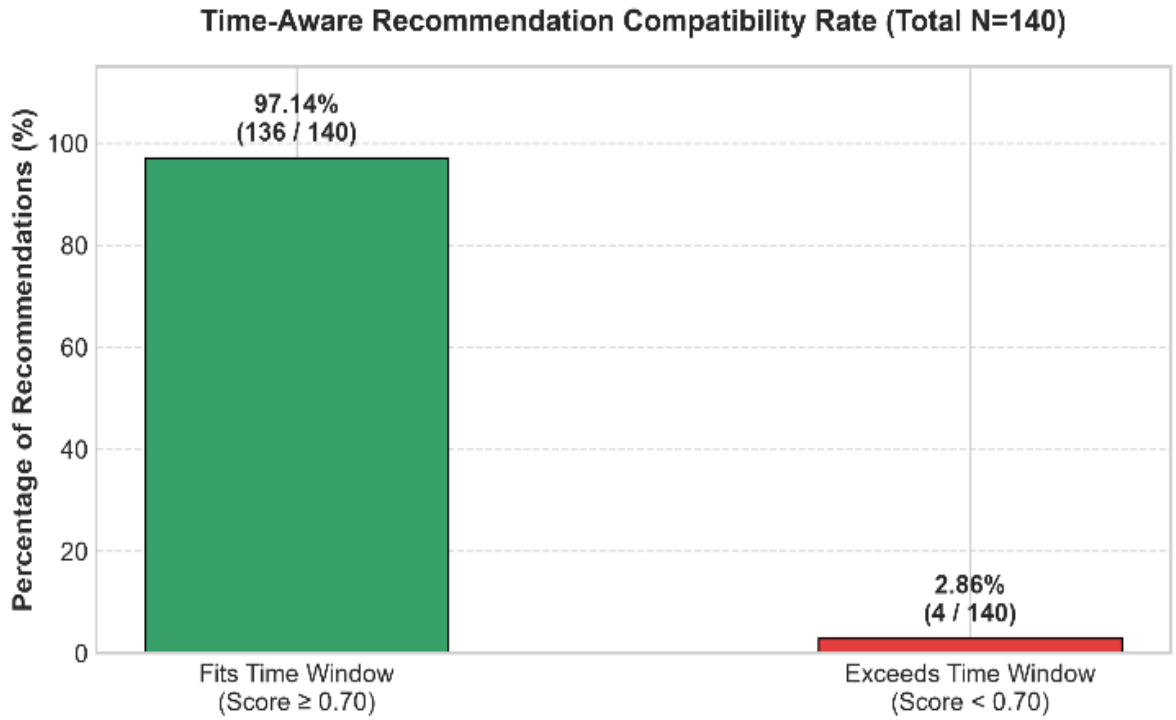


Figure 4: Time Compatibility Graph

C. Implementation of proposed approach

In below Figure 5 shows the Dashboard of Shesphere which exemplifies Time-Aware Recommendation as the recommended videos match the user's interest in Cooking. In addition, the recommendation suggests the most relevant materials on the basis of their tags, categories and subtitles, which are defined by the content of the video. The cards also indicate the degree of match in percentages, which shows the accuracy of the recommendation algorithm. Specifically, the cards on the 93% and 89% match are recommended in accordance with tags and categories. The suggested videos have a certain length, and their durations are matched with the set time of 1 hour to fit the most relevant materials. This way, user would not get overwhelmed by information and could choose the length of suggested videos, fitting them to their daily schedules.

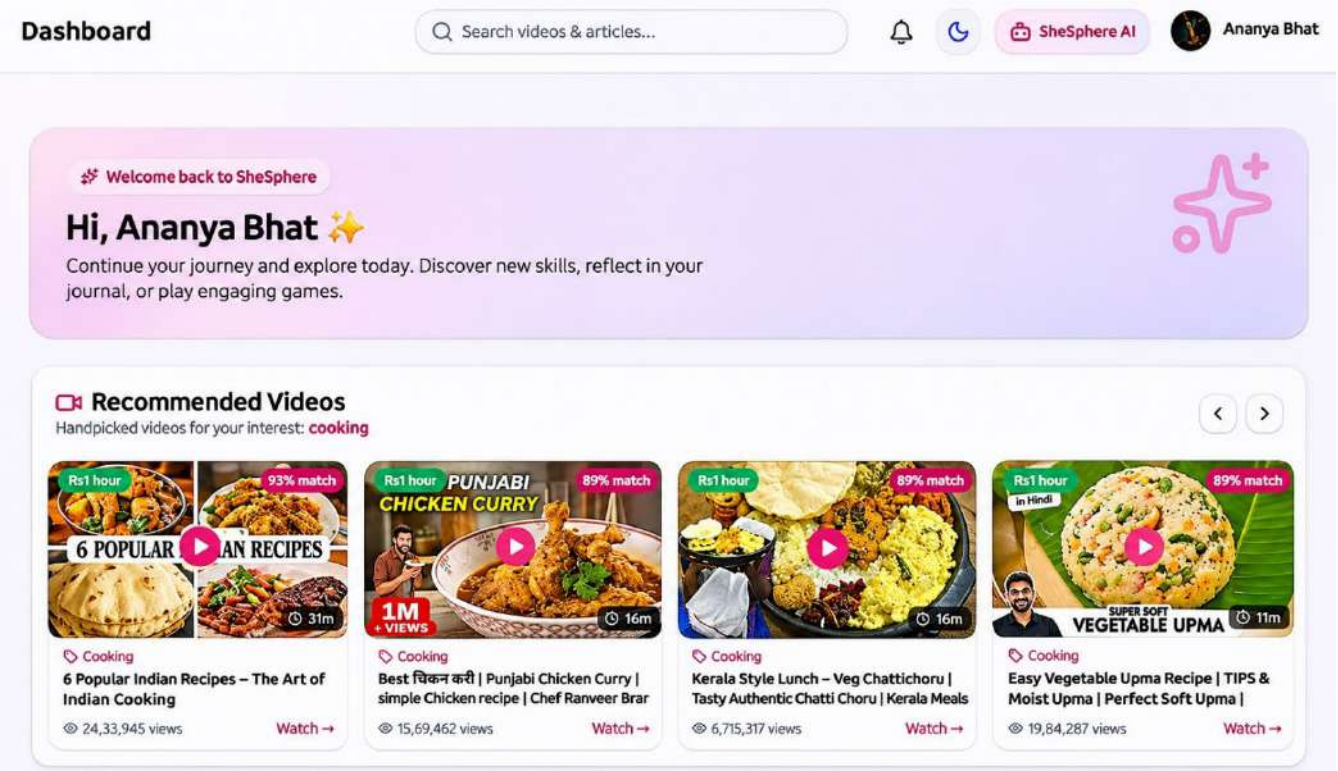


Figure 5: Dashboard of SheSphere

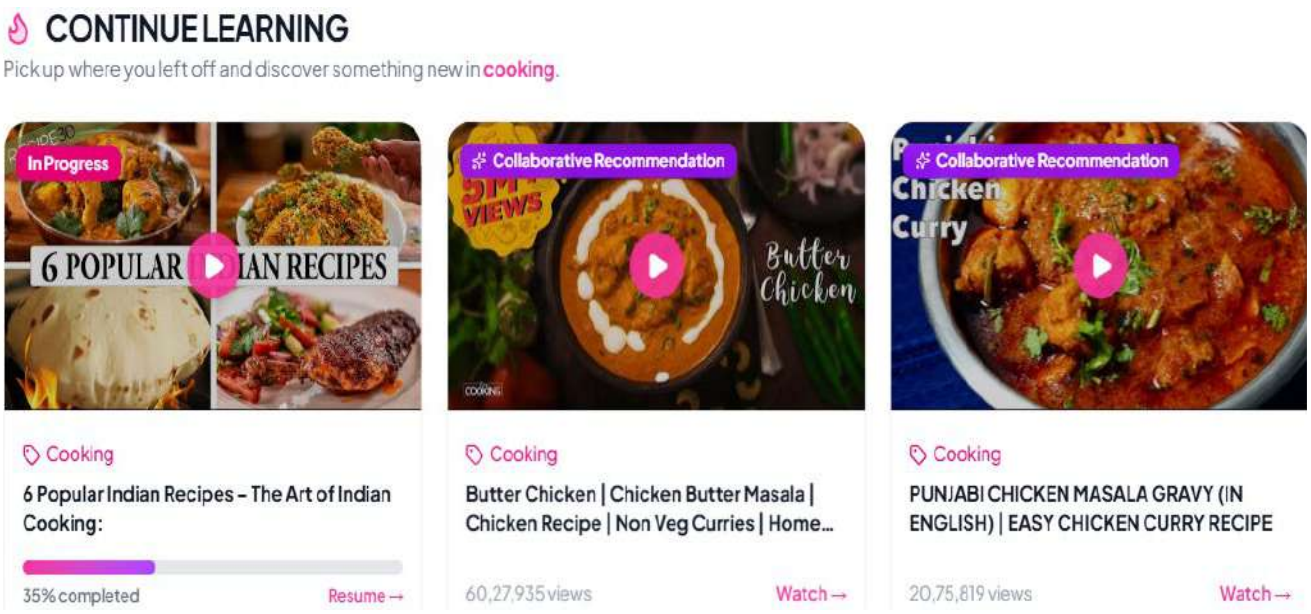


Figure 6: Collaborative and Content based Filtering

The Continue Learning section displays Collaborative and Content-based Filtering Recommendations as shown in Figure 6. Similarly to the dashboard, the recommended cards match the user's interests in Cooking. The recommendations also consider user's actions, such as progress in videos and likes. The cards labelled with "Collaborative Recommendation" suggest similar content in accordance with the user's actions on the basis of other user's behaviour.

In below Figure 7 shows the Marketplace module which offers the user a space to display and sell their own products. The user is able to input information about the products they desire to sell, view products in the marketplace, manage their own products and view their orders. The system allows the user to both buy and sell products within the same application while still being able to access other features, such as the learning and community modules. The marketplace feature is also connected to Razorpay Test Mode, a feature that enables the user to experience the payment process, showcasing how the payment management system works along with the rest of SheSphere's modules.

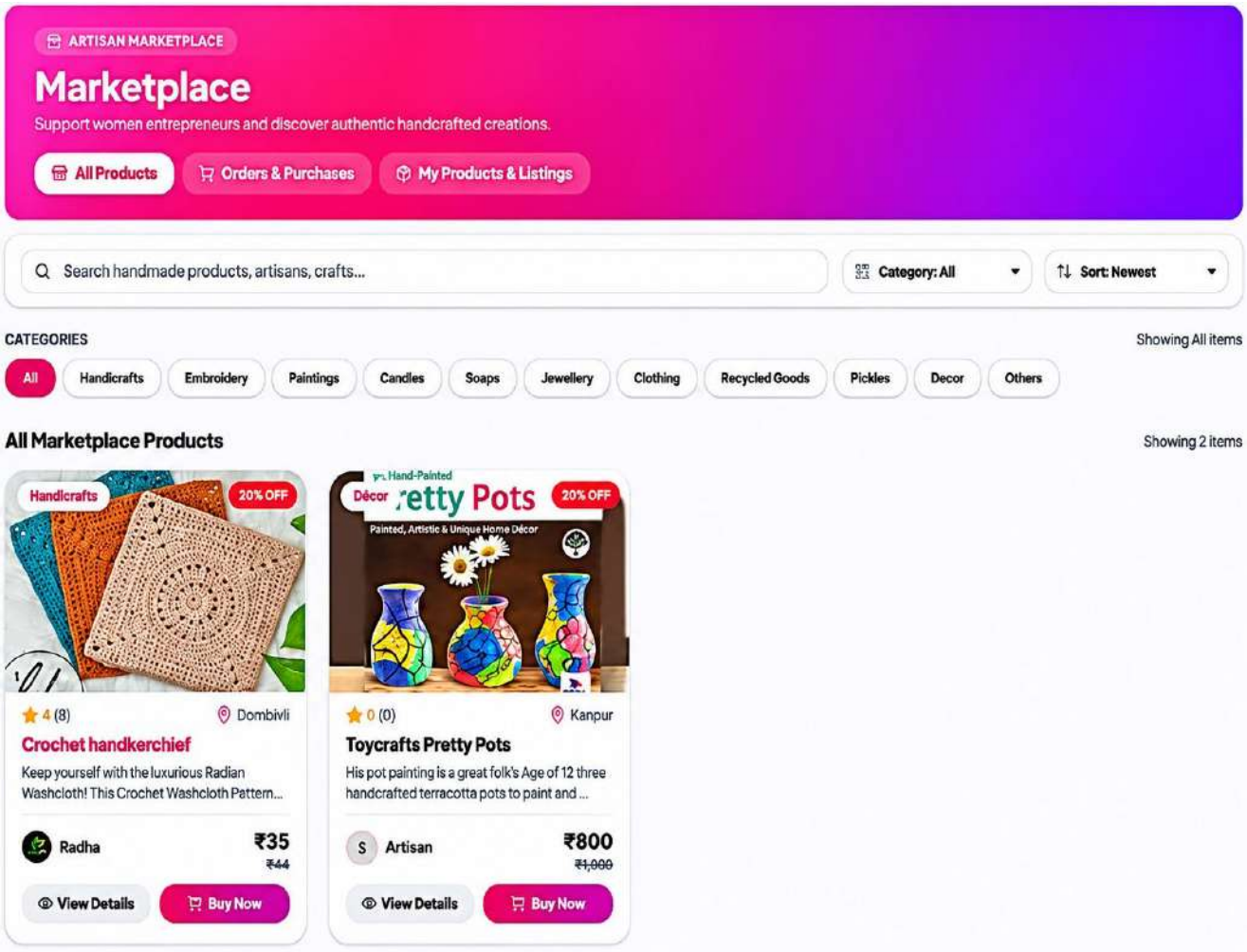


Figure 7: Marketplace of SheSphere

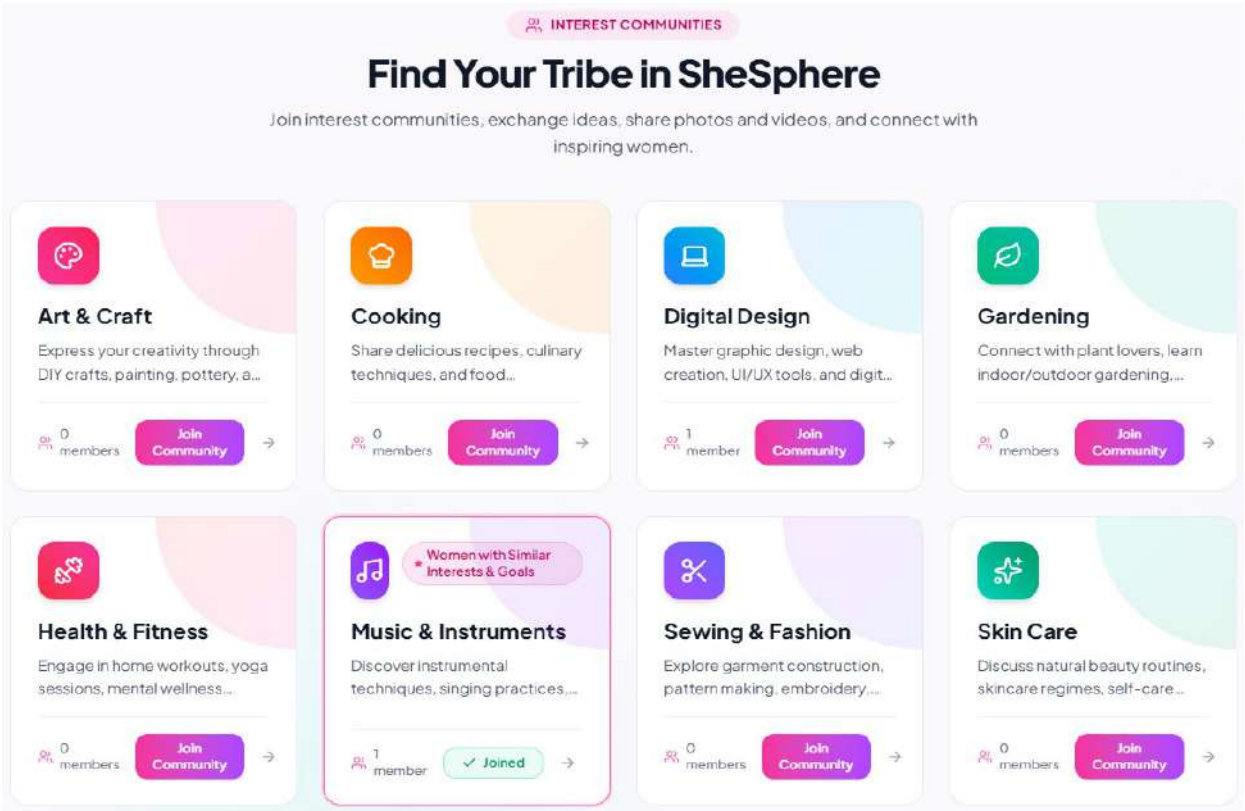


Figure 8: Community of SheSphere

The Community module offers interest-based spaces for a user to interact with other members, post, share information, comment and participate in discussions. Users can join the communities on their selected interests to learn from like-minded individuals and share information as shown in the Above Figure 8 Such a feature promotes the social aspect of interaction and engagement with similar learners in addition to the personalized learning experience offered by the SheSphere.

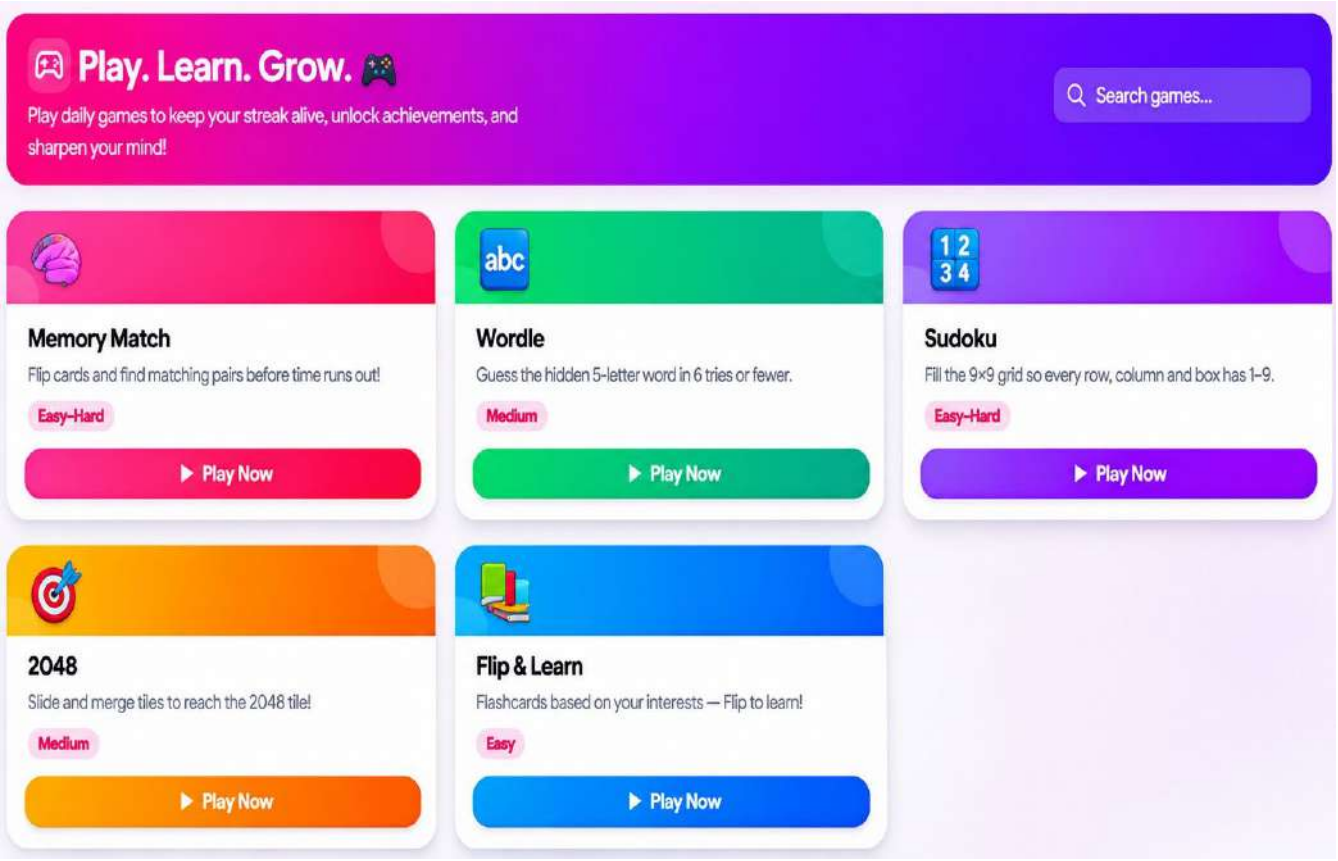


Figure 9: Games in SheSphere

Figure 9 shows the Games in SheSphere. The Games module offers engaging educational content where the user can learn and improve their skills via an interactive gameplay. The feature helps in boosting the user's engagement through a fun learning experience in addition to the learning, community and personalization pillars of the platform. The user can also track their game progress which can promote their overall progress within the SheSphere.

D. Database Implementation

SheSphere utilizes MongoDB as a database system with Mongoose as the underlying database management system. The database comprises different relevant collections to the modules in the platform, namely: Users, Videos, Articles, Watch History, Video Likes, Communities, Community Members, Community Posts, Comments, Likes, Products, Orders, Journals, Game Progresses, Notifications, Messages, Reviews, User Activities and other related collections as shown in Figure 10.

The users collection contains the user profiles and personalization data including the user's interests, language, education, age, daily free time, clusterId, videos watched, learning time, XP, level, streaks and more. The recommendation system utilizes such user content interaction data in order to offer a personalized experience through the clustering of users according to their interests.

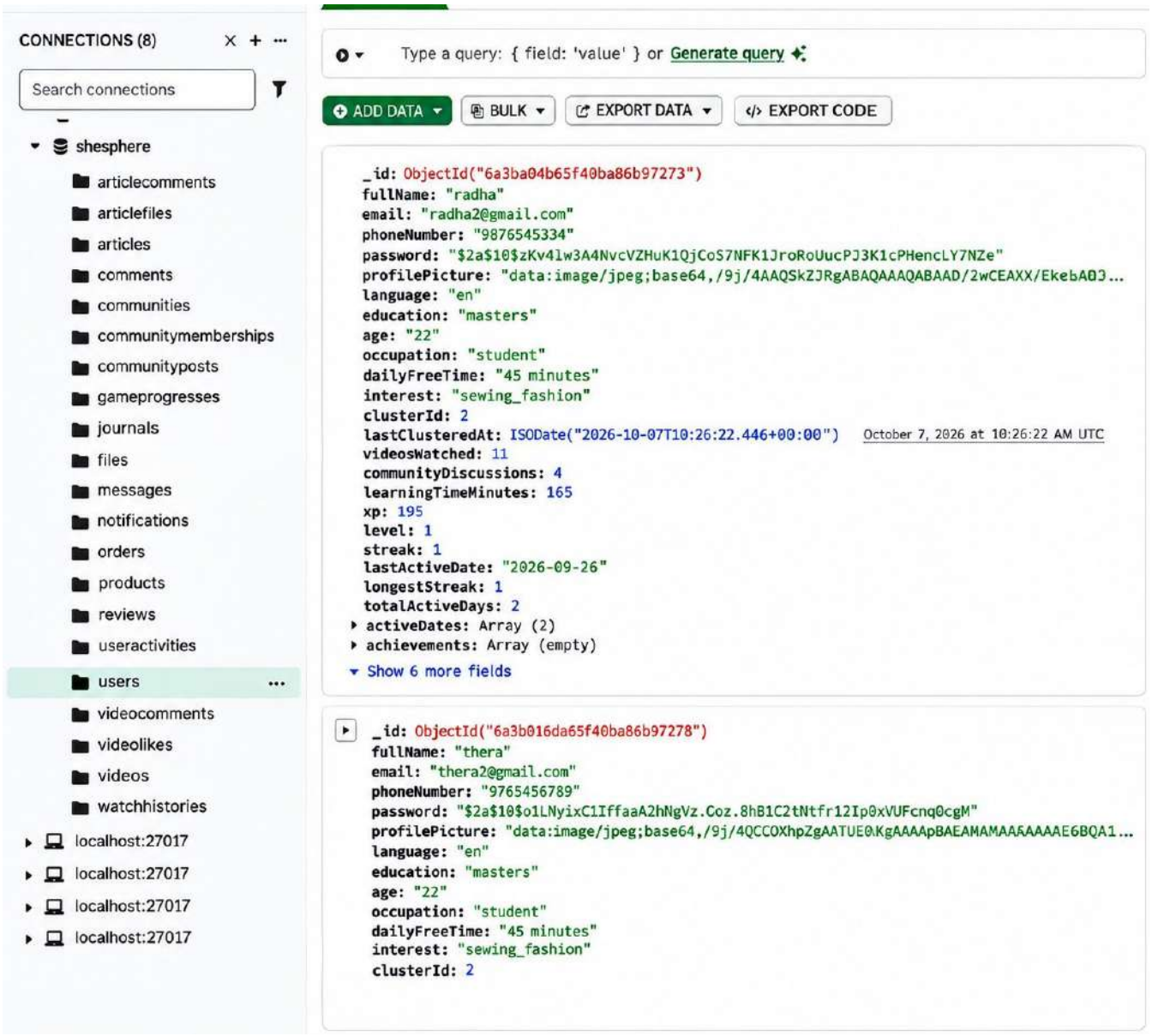


Figure 10: View of MongoDB Compass Database

VII. CONCLUSION AND FUTURE SCOPE

SheSphere – An Integrated Digital Ecosystem for Women's Learning, Community Engagement and Entrepreneurship was developed to integrate personalized learning, skill development, community engagement, personal growth and marketplace services into a single web application. As it was designed to empower female homemaker learners, it intended to give them an opportunity to further expand their skills and take a chance at finding new career opportunities. In particular, the system involved a combination of K-Means Clustering, Content-Based Filtering, Collaborative Filtering and Time-Aware Recommendation to recommend videos and articles to its users. The platform also incorporates features related to the existence of communities, a marketplace, journal, educational games, multilingualism and a chatbot. The current implementation of the system only serves as a proof of concept. Thus, further testing and improvement of recommendation systems within a greater audience would be required to see if the results would be applicable to real-life scenarios. Furthermore, more data would have to be gathered to see how the system would perform with different types of users. The future scope of this project entails improving the recommendation system by including more attributes in the analysis process to transform it into an intelligent system. More languages and interests should be added to support more users in their learning and shopping needs. Additionally, the application can be enhanced by adding more items, services and products. The temporal recommendation method can be improved by implementing a payment gateway, adding more services to the marketplace, and developing a mobile application. Community features can also be integrated to offer live interactions and advanced data mining and analysis to improve recommendation accuracy. Consequently, the application will be more personalized, helpful, and user-friendly while providing the much-needed community and marketplace for female users.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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