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RESEARCH ARTICLE

A Recommender System for Adaptive Examination Preparation using Pearson Correlation Collaborative Filtering

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Abstract

Distance learning is any type of far-off instruction where the understudy isn't actually present for the exercise. It is blasting gratitude to the force of the Internet. Distance learning plays a vital role for examination preparation where multiple choice questions can be utilized to evaluate the performance of students. Multiple Choice Question (MCQ) is a type of question used in the examination to evaluate the performance of students accordingly where usually four options are given along with the question, and one has to choose the correct answer. This research includes a simulation model that has been built to keep the learners continue to learn the subjects they might be weak in. We have developed a methodology that may guide a student to update his/her area of weakness by using a recommender system based on Pearson Correlation Collaborative Filtering approach. The paper describes a recommender system that will keep track of a learner's profile and create an adaptive training mechanism using the performance matrix.

Key Words: *Recommender system, Examination preparation, Adaptive e-learning, Pearson correlation collaborative filtering, Distance learning*

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1. Introduction

The COVID-19 pandemic affected worldwide [1,2] and changed the way of living in many ways. Due to the imposes of lockdown and social distancing schools have come to closing. Like other countries Bangladesh is also facing the crisis [1] and battling combinedly to overcome this pandemic. A diverse change is in action. The education sector is not different either. The state-owned Television network in Bangladesh, Bangladesh Television (BTV) has started broadcasting class and subject wise lessons for students. To ensure that learning continues from home during school closures, the Government is working with UNICEF to help implement effective remote learning programs using TV, radio, mobile phone, and Internet platforms. In our education system, the Multiple-Choice Question is a type of technique to evaluate the performance of a student. This is one of the preferred methods from national level examination (i.e., Bangladesh Civil Service-BCS) to international level examination (i.e., Graduate Record Examination- GRE) to assess someone. There are some advantages of MCQ. These are- students have quick preparing times; there's no space for subjectivity; students can pose more inquiries; it takes less effort to finish a numerous decision question contrasted with an open inquiry; respondents don't need to detail an answer however can zero in on the substance. Hane et al. said that the multiple-choice procedure, which draws questions and response options from a pool, is certainly the most advanced of the automated tests [3]. They prepared a solution on evaluation of individual knowledge where the responses can be correct in more than one or ambiguous. For the solution the test data of all participants are compared not only with the correct solution, but above all pairwise among each other. So they tested peoples knowledge on internet by grouping and calculated the mean of answers from every group. A Nonmetric multidimensional scaling (NMDS) map was created to show a clear view of overall result. The result concluded as in terms of the use of multiple choice questions in E-learning curricula and for tests conducted through electronic means, this comes as a great relief, as it is not always possible to evaluate all questions in a normatively perfect manner in advance.

If we talk about distance learning then- distance learning is unmistakably not quite the same as standard instruction as far as an understudy or instructor's actual presence. Generally, it converts into expanded opportunity for the two students and teachers, yet it likewise requires higher levels of control and wanting to effectively finish the course of study. The improved opportunity of distant learning is most unmistakably found in the way that understudies can pick courses that fit their timetables and assets. (Instructors can do likewise.) and on account of advanced learning, understudies can likewise pick the area and instructing styles that best suit their necessities. There are some advantages of distance learning. These are- availability for those living away from the instructional hub; no exercise in futility or different assets in vehicle and driving to a focal area for each class; adaptability to concentrate in any helpful area with an Internet association; without a moment to spare learning; more freedoms to contemplate the most current material accessible; adaptability for those with unpredictable plans for getting work done; openness for those with limited versatility; openness for those with family obligations. The procedure of throwing large questions for descriptive answers on a distance E learning platform may not help the learner to know or assess them more. The answer evaluation techniques may become ambiguous and not worthy. Whereas Multiple Choice

Questions (MCQ) can be very relevant or easier to crack and get the answer from the learners view.

This paper focuses on guiding every student who is willing to learn in respective topics to update his/her area of weakness. Based on the user's previous exam performance the recommender system recommends questions. If a user gets lower marks, the system recommends more questions to improve on that particular subject or area. The finalized objectives of our work are included as follows: recommend adequate information to the learners; and make the recommendation adaptive based on the learner's performance.

2. Literature Review

There is a vast array of works of machine learning in diverse area i.e. Classification of Fake News [4], Facial Spoof Detection [5], Image classification [6], Auditory attention state [7], Computational biology [8], Trust management for IOT [9], Text processing [10,11] are going. On the e-learning context to help the learners learn in an easy, fun, and competitive way. We can divide our related works section into two parts: adaptive e-learning and recommender system.

2.1. Adaptive E-learning

Awadh A.Y.Al-Qahtani showed the pros and cons of e-learning and blended learning and how it is important in the higher sector of education. For this investigation, they chose two groups of random students from a university and concluded that both learning approaches had the right way for the further expansion of higher education [12]. They have measured the standardized mean difference to compare different groups of learning system. The result suggest that blended learning can support students' learning more effectively than e-learning or face-to-face teaching. In another study, Joo-Chang Kim introduced a learning model based on an adaptive prediction model for inclusive intelligence. This type of model is used in the life care platform to calculate the similarity for the recommendation in the mining system. This dedicated model only works in health care [13].

Dwivedi et al. presented an effective model called the Learning path recommendation system which was for e-learners. Here the author used a variable-length genetic algorithm by using the knowledge level and learning skills of learners [14]. Abidi and Goh had flourished distance exam preparation and evaluation service which was value-added, technology-enriched, and web-enabled. Their students can attend the content personally and prepare themselves so that they could sit for the test offline [15]. Here the learner can personalize the content and prepare and test offline. An adaptive online exam system is proposed in the research of Vagci et al. which determines different questions sets the automatic and interactive way for every independent student [16]. The system consists of three-layered structures. For data storage: a database; and for application and clients: a server (which were connecting to the appliance server) had been utilized.

As for database, MYSQL is employed. The Macromedia Dreamweaver 8 software was used for the preparation of the system interface. Due to its improved capabilities and conveniences,

Dreamweaver was one of the most favoured HTML editors and makes server-based languages for used in building interactive pages. JavaScript language was used in the adaptive web-based exam framework to allowed dynamic user access; to allowed it to be sampled on the same page; and to perform perforations. The user name and password were the keys to the system in the web-based exam system to identify a particular user. Because any entity with a username and password is deemed allowed to enter the system, the confidentiality of information is important. For students registered for the course and for the lecture, the administrator will create the user name and password automatically. However, the proposed system does not provide a recommendation technique. A combination of tracing techniques using computer-based learning environments is established by Poitras et al. [17] Statistical and computational approaches were combined by this technique evaluate practice, skill acquisition, and a single-agent system, refinement tool. Users applied the skills used the rule-based reasoning system that permits the pedagogical agent to accommodate the instruction. The result shows if inappropriate skills are applied. Here author targeted 22 undergrade students (6 men,15 women) to test SRL (self-regulated learning) skill. The accompanying consideration models were picked to test the members in this investigation, in view of the understudy populace that is focused by the plan rules as follows: members must be local English speakers; not presently selected any set of experiences history related program; and new to the point to be learned. Though understudies were gaining SRL abilities in the Training Module, they had the opportunity to rehearse. Also, refine these abilities in the Inquiry Module.

In the perspective of a complex adaptive system, Mennin discussed the small group where there was problem-based learning [18]. The understanding and practice of problem-based learning are also proposed. This is a scheme of learning in health professional institutions and complexity science provides an understandable theory of this method. Different types of adaptive hypermedia and User Modeling were mentioned by another research Ishak et al. [19] This process creates a model of the preferences, goals, and knowledge of each particular user. That model was used for the interaction of the user so that the user could adopt this whenever they need. Yaghmaie et al. proposed the base of a framework model which was combined on multi-agent systems and Semantic Web ontology and Object Reference Model for learning adaptation, content storage sequencing [20]. Both of these contents were shareable. System effectiveness was revealed by the results.

2.2. Recommender System

John K. Tauras et al. had established a proposal combining context awareness, latter pattern mining, and collaborative filtering for recommending objects [21]. They had fused setting mindfulness and student's successive access designs into the suggestion cycle to accomplish improved personalization of recommendations. The proposed crossover suggestion algorithm additionally utilizes GSP calculation for mining the weblogs and finding the student's consecutive access designs. Maravanyika et al. proposed a recommender framework-based versatile e-learning structure for customized instructing on e-learning stages [22].

The paper identified difficulties of helpless commitment in online separation settings and offered to empower the identification of issues or obstructions that might be encountered when supporting students in their journey to lessen disappointment and Dahdouh et al. built up a

dispersed courses recommender framework for the e-learning stage which means to find connections between understudy's activities utilizing affiliation rules strategy to assist the understudy with picking the most fitting learning materials [23]. In an examination of G. Carenini et al., they proposed a bunch of methods to intelligently select what data to inspire from the client in circumstances in which the client might be especially inspired to give such data where they are focusing on recommender frameworks dependent on unadulterated collective filtering [24]. Sun introduced to integrate research in dialog systems and recommender systems into a novel and unified deep reinforcement learning framework to build a personalized conversational recommendation agent [25]. An exploration suggested learning objectives and create learning encounters on a versatile e-learning system where Capuano et al. utilized IWT (Intelligent Web Teacher) that portrayed the educational area by methods for an Ontology [26]. L. Norez et al. proposed to tackle the issue of data over-burden by choosing things (business items, instructive resources, TV programs, and so on) that coordinate the customers' advantages and inclinations, data put away in electronic wellbeing records, internet shopping, e-learning, amusement presented another filtering technique, fixated on the properties that portray the things and the clients [27]. Here they introduced another methodology called property-based collaborative filtering (PBCF) which completely decouples clients and their properties on the one hand, and things and their properties on the other. Thus, it is conceivable to fabricate a grid of qualities speaking to the amount one thing highlight in influences the appropriateness of a thing for somebody with a specific client property.

Zhang et al. built up the Explicit Factor Model (EFM) to create logical recommendations, meanwhile save a high expectation precision for which they first removed unequivocal item highlights and client suppositions by express level slant investigation on client audits, at that point produced the two proposals and discommendations as indicated by the specific item highlights to the client's advantages [28]. Moreover, intuitional highlight level clarifications concerning why a thing is or isn't suggested are created from the model besides online test results on a few genuine world datasets exhibit the favorable circumstances of their system over serious standard calculations on both rating expectation and top-K proposal errands. Online tests demonstrated that the definite clarifications make the suggestions and discommendations more persuasive on the client's buying conduct. In an exploration, Nilashi and Ibrahim demonstrated the principle of information mining methods utilized in the plan and usage of recommender frameworks [29].

The technique of information mining commonly acted in succession: Data Preprocessing, Information Analysis, and Result Interpretation where they additionally depicted the subparts of every method and their benefits faults. Dwivedi et al. utilized synergistic filtering-based suggestion strategies to suggest elective courses to understudies, contingent on their evaluation focuses acquired in different subjects. Comparability Log-probability is utilized to find designs among grades and subjects and RMSE between real evaluation and prescribed evaluation is utilized to test the suggestion framework. Through this work, they identified the materialness of the recommender framework for the immense size of instructive information and identified how schooling information can be planned to the thing in recommender frameworks [30]. They used a collection of data from various Central Board of Secondary Education (CBSE) around India. They believed that if they collect data from all schools around

India, the data size will expand exponentially, so they used the Hadoop platform to manage the data. The data collection included a list of student grade points in various subjects, which was compared with the choice of user objects in the suggestion framework for item-based shared filtering. They used item-based objects, Mahout Deep Learning Library Suggestion Methodology. The Mahout recommender model used the input data of a choice entity in a triple format. Their future strategy was to use the recommendation framework built on a hybrid model in the future to boost the recommendation's accuracy. Planning to use recommendation mechanisms to propose college job choices to students, based on some existing evidence from students in the previous class. It is significant to find a reasonable substance in the learning cycle regardless of the association to spare time and rapidly engage in the workflow [31]. That is the reason Nikitina et al. presented new frameworks that can successfully suggest the vital instructive material for clients based on their inclinations to send corporate information to any worker of the organization under corporate preparation.

Tseng et al. proposed a Recommended System that can be utilized to Online Course Learning System that suggested the best learning way of learning objects for students to online self-learning, or to Recommended System that gives the premise of self-learning solutions for Suggested Form of Remedial Course [32]. they suggested a recommendation framework focused on an online learning and assessment system with learning success analysis that incorporates both usability and validity analysis and a process for optimizing feedback. In this study, a recommendation framework that incorporates the two-phase blue-red tree rule space model and the recommendation system of the best learning path is proposed to efficiently examine the relationship between the success of the solution for MTA (Microsoft technology associate) and the passing rate of the credential. Budimac et al. proposed a web based tutoring platform and given the name of Protus [33]. This program applies both recommendation and adaptive hypermedia techniques which directs the user to relevant links to learn different ways. They have used Collaborative filtering and association rule mining to determine suggestions.

The overall reviews of literature lead us to a research gap where our work is a new product which is specially designed for students trying to pass the BCS or GRE examinations from Bangladesh and other countries of the world.

3. Methodology

In most exam preparation platforms random selection of questions is utilized from various question banks. Thus, resulting in poor performances as weaknesses of examinees is not considered which causes a lack of confidence and motivation to take exams. In our proposed system collaborative filtering approach is utilized which will keep track of students' profile and create an adaptive training mechanism using the performance matrix. The system model architecture for adaptive examination preparation is shown in Figure 1. Nevertheless, a user can also take exams of higher difficulty level using the recommender system for superior exam preparation. The target user of the system is students of various backgrounds.

This recommender system will recommend questions into two categorizations as follows: similar or correlated questions of correctly answered questions by the students for lower

difficulty level; and dissimilar or uncorrelated questions of lower difficulty level questions for the higher difficulty level.

Students can take multiple exams using this recommender system. Exam scores will be stored in database to keep track of users' profile. Similarity among the questions in the database and correctly answered questions will be calculated using Pearson Correlation Collaborative Filtering technique. Correlated questions answered correctly by the students will be recommended for lower difficulty level. Uncorrelated questions of lower difficulty level questions will be recommended for higher difficulty level. Adequate questions will be recommended to ensure better performance of the students in his/her area of weakness evaluated by the recommender system. Therefore, the recommender system will boost up students' motivation and guide to improve students' performance gradually.

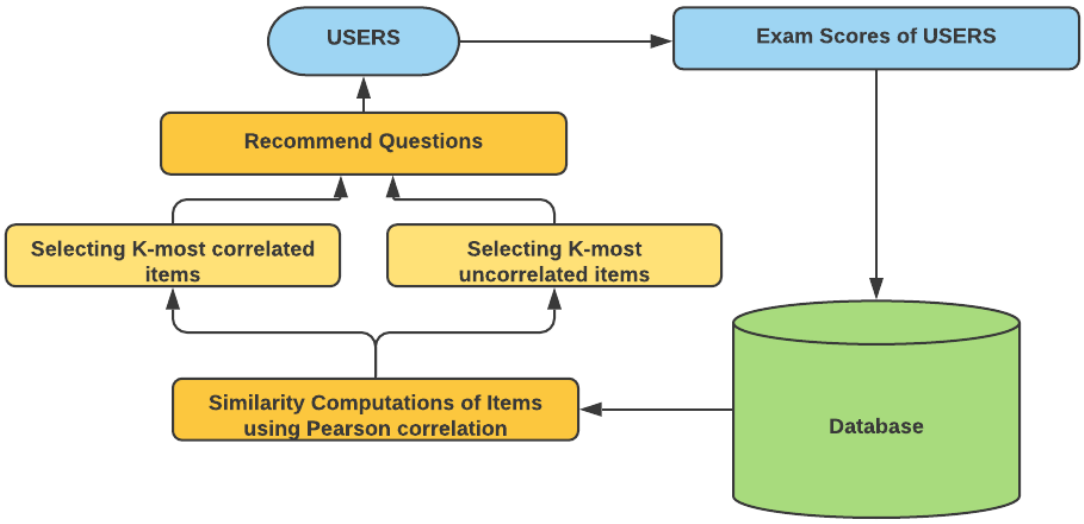

Figure 1: *Recommender System Architecture for adaptive Examination Preparation System using Pearson Correlation Collaborative Filtering technique.*

3.1. Data Sets

For our question recommender system, we have used the question bank and user scores dataset. This dataset contains 20K data points of various questions and users. We have gathered the question bank and user scores dataset over various time intervals. The scores dataset consist of 20000 score values taken as exam scores from 500 examinees as training data. The question bank dataset includes 2000 questions of different difficulty levels of several courses. We have taken the score values as exam performances obtained from examinees in a single scores.csv file. The format of the scores.csv is as follows User_ID: Question_No: Score: Timestamp. When a new user will sign in to the system, a unique User_Id will be provided by the system. User_Id of the given scores.csv dataset ranges between 1 to 500, Question_No ranges between 1 to 2000, and the Timestamp value represents the time intervals in seconds identifying when the exams were held. Score values are taken on a scale of 0 to 5 shown in Figure 2. It is observed that the histogram of scores values obtained from students is

representing normal distribution where the score values are most likely residing between 3 and 4 on a scale of 5.

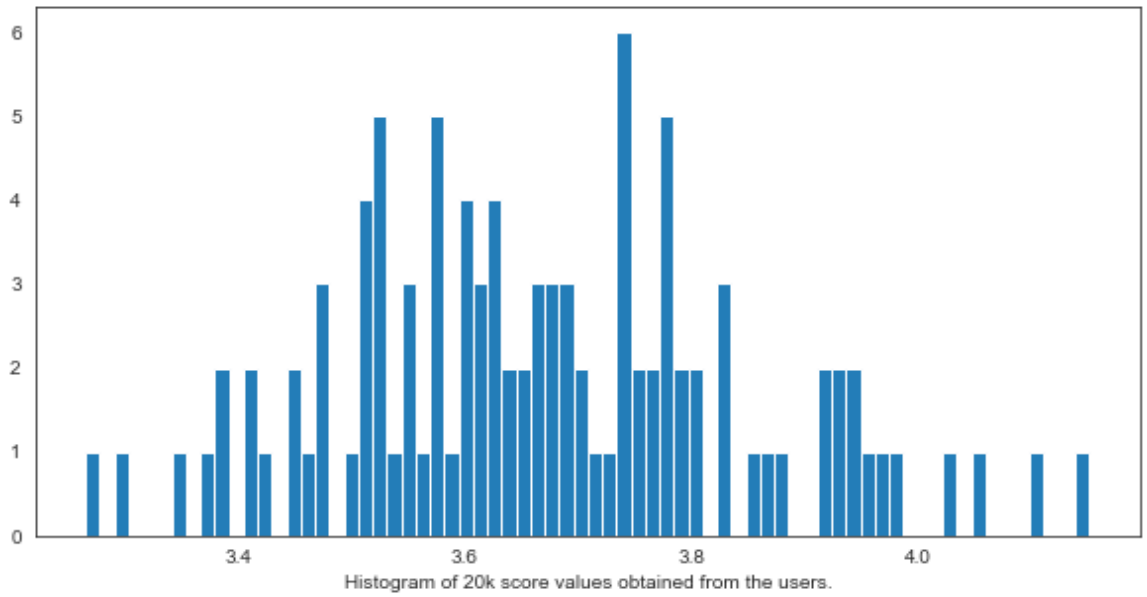

Figure 2: *Histogram of 20k score values obtained from the users.*

The format of the question_bank.csv is as follows Question_No: Question: Course_Name. The dataset has a minimum of 50 score values and a maximum of 500 score values obtained from each of the users which is shown in Figure 3. The recommender system uses Pearson correlation among the questions to calculate the similarity and dissimilarity. Therefore, a decent no. of answered questions from each user is taken into count.

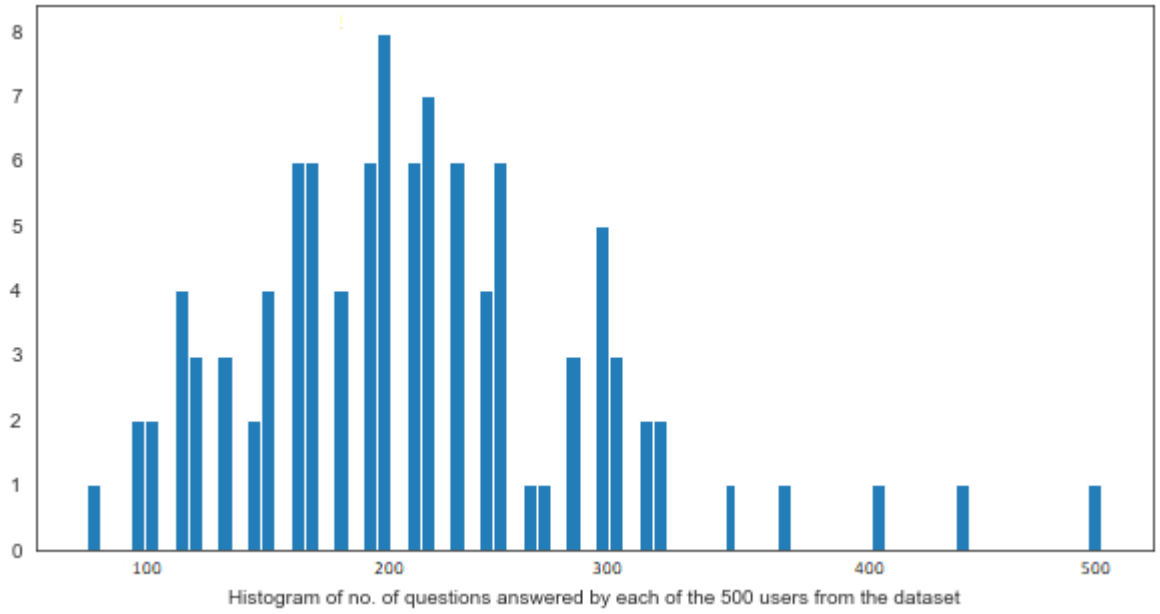

Figure 3: *Histogram of no. of questions answered by each of the 500 users from the dataset.*

Finally, an illustration of score vs no. of answered questions by each of the 500 users is shown in Figure 4 by which we can visualize the dataset which is utilized to demonstrate the recommender system architecture of adaptive Examination Preparation System using Pearson Correlation Collaborative Filtering technique.

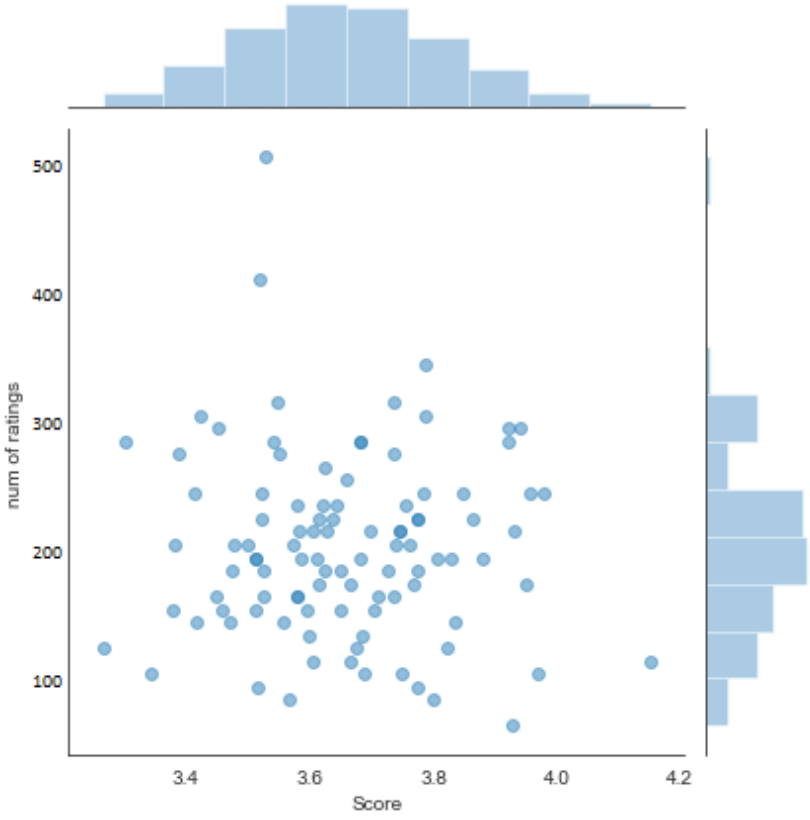

Figure 4: *Histogram of score value vs no. of score ratings attained by the users.*

3.2. Similarity Weight Calculation

To decide how solid is the similarity among the questions, the Pearson correlation coefficient equation is followed to create what is alluded to as the coefficient weight. The coefficient weight can run between-1.00 and 1.00. On the off chance that the coefficient esteem is in the negative reach, at that point that implies the similarity between the questions is contrarily associated, or as the positive reach similarity between the questions is similarly associated. Pearson correlation coefficient among the question data sets is calculated using the following formula

$$pearsonsim(m,n)=\frac{\sum_{u\in Umn}(S_{um}-\overline{S_u})(S_{un}-\overline{S_u})}{\sqrt{\sum_{u\in Umn}(S_{um}-\overline{S_u})^2\sum_{u\in Umn}(S_{un}-\overline{S_u})^2}}$$

where,

S_{um} is representing the scores obtained to any item m by any user u.

S_{un} is representing the scores obtained to any item n by any user u.
$\overline{S_u}$ is representing the average scores obtained by all the users in the score's matrix.
The calculation of item similarity is shown using the pivot table in Table1.

Table 1: *Similarity Weight Calculation using Pearson Correlation among the questions of the data sets.*

Similarity Weight Calculation using Pearson Correlation

question	The Opium war id held between which two countries?	'Not bene' means –	A constitutional monarchy provides what power to a monarch?	A speed limit is the _____ legal speed that you can travel on the road.	AFTER: BEFORE:
question					
The Opium war id held between which two countries?	1.000000	-0.107472	0.373395	0.090998	0.127082
'Not bene' means –	-0.107472	1.000000	-0.246692	-0.099388	-0.491679
A constitutional monarchy provides what power to a monarch?	0.373395	-0.246692	1.000000	0.122669	-0.096956
A speed limit is the _____ legal speed that you can travel on the road.	0.090998	-0.099388	0.122669	1.000000	0.249786
AFTER: BEFORE:	0.127082	-0.491679	-0.096956	0.249786	1.000000

Table. 1 is shows the similarity weight calculation using Pearson Correlation among the questions data sets.

3.3. Neighborhood Selection

The question set for an exam will comprise a specific no. of questions from each course. So, using the previous performances of users a recommended question set will be provided to the users every time so that a user can improve his performance gradually which is showed Table2.

Table 2: *Finding question similarity among the question data sets for the new user's data.*

Finding question similarity of new user's response

	The Opium war id held between which two countries?	'Not bene' means –	A constitutional monarchy provides what power to a monarch?	A speed limit is the _____ legal speed that you can travel on the road.	AFTER: BEFORE:	After _____ smoking, they let the cigarette fall on the wood floor.	All of us are devoted _____ one another.	An interest group hires lobbyists to	Antonym of DENIGRATE is _____?	CATTLE : DROVE : :	...
0	-0.347658	1.039384	-0.580518	0.348125	-0.477156	0.071136	1.204983	-0.238464	0.215924	-0.742726	...
1	-0.165127	-0.152693	0.027577	-0.051890	0.031680	-0.087847	-0.086933	0.500000	-0.059281	0.163055	...
2	0.302918	-0.311437	0.064902	0.490140	0.582762	0.247924	-0.457442	-0.592793	0.074577	0.088175	...
3	0.118606	-0.201222	-0.332046	-0.002406	0.293652	0.727480	0.202974	-0.446852	0.535908	-0.130120	...
4	-0.015272	-0.224835	0.026552	-0.129022	0.285459	0.071960	-0.009288	0.154375	0.094264	0.168948	...

Henceforth this choice of neighbors must be accomplished more cautiously in order to not infect the standard of suggestions created. Subsequently, as showed in Figure 5, we will pick the K most correlated neighbors having the most noteworthy similitude contrasted with others for similar or lower difficulty level questions based on similarity index where similarity index is calculated using our system defined function.

Recommended Similar Questions:	Similarity Index
That was __________movie I have ever seen.	2.409521
Who is the First Test Tube Twins Babies in the World?	2.110618
Whose winter residence did potala palace serve as till 1959?	2.075517
There is something wonderful ____ him.	1.995085
Who among the following emphasized the 'Five Relationships'?	1.801458
Which among following is called "Gift of the Nile"?	1.687928
I promise to ________ you in all circumstances.	1.503905
There is quite tenuous evidence _________it.	1.477002
Which of the following tribes does not share its name to a mountain peak?	1.343691
In the test, we will _________ your work and then give you detailed feedback.	1.152355

Figure 5: *Recommending K most similar questions based on Similarity Index.*

K most uncorrelated neighbors having the most noteworthy dissimilarity contrasted with others will be picked for higher difficulty level questions so that a user can take higher difficulty level exams as well. Figure 6 given below describes the K most dissimilar questions based on similarity index where similarity index is calculated using the system defined function.

Recommended Dissimilar Questions:	Similarity Index
The antonym of 'Imbecility' is –	-1.602621
Who was the modern world's first woman head of government?	-1.544786
When did the first Railway Train begin to carry passengers and freight?	-1.207858
I shall look _________ the matter.	-1.188054
What are names of two missions to be launched by NASA to explore the ionosphere?'	-1.166819
If she is not interested, we will __________ the proposal.	-1.161341
Which state to be 1st state to legalize mask-wearing?	-1.075020
Which country topped the list on 'World Happiness Index', 2015 published by the SDSN?	-1.013320
Do not stay in the grasslands after dark, as some animals become _________when they see humans.	-1.012702
The tallest bridge in the world Millau Viaduct has been constructed over the river __________.	-0.963603

Figure 6: *Recommending K most dissimilar questions based on Similarity Index.*

Finally, a specific number of questions for each course will be selected from the question bank making a personalized question set for different users according to the users' competency where the already answered questions will be discarded. Hence, a user can take numerous exams of lower difficulty level and higher difficulty level as well to improve his/her performance gradually.

4. Conclusion

Recommendation frameworks are suitable for various issue fields and a wide extent of employments including articles, documents, books, products, and movies. Utilizing different recommender frameworks, customized proposals are provided to different users depending

on the user's inclinations. Correspondingly, recommendations that are provided by the recommender systems should fulfill the client's preferences and the recommendations should be made dependable and justifiable to satisfy the clients. In this paper, we have driven an implementation of a recommender system utilizing collaborative item-based filtering methodology in the education system and appraised the foremost way for exam preparation improving candidate's preparation for exams continuously using performance matrix. Our outcomes hold the assurance of utilizing a collaborative filtering approach in any event, for large scope data as well. But time complexity gets higher for a very large scale of data using the proposed recommendation system which is an area to work in the future.

Conflict of interests: The authors declare that there is no conflict of interest.

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