Real-time personalization and recommendation in Adaptive Learning Management System

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ORIGINAL RESEARCH

Real-time personalization and recommendation in Adaptive Learning Management System

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Abstract
Various e-learning environments have been developed to provide sufficient materials for learners and thereby guide them to gain knowledge in any domain. Even though there were several factors that determine the motivation of the student, the skill set possessed by them is definitely an important factor. Hence in our proposed work, the behavioural and educational skill of the learners is tested by a skill test and learning content is provided only based on their skill test evaluation reports. The entire process is done by real time personalization based Adaptive Learning Management System and Personalized Page Rank algorithm. Finally, the Navies' Bayes classifier was employed to classify the learners based on the performance over the skill test. Learners on their own can express both the optimistic and adverse skills that considerably impact the adaptive learning in e-learning environment. High skilled categorized learners are offered with advanced, intermediate learners with moderate and beginner or slow learners are provided with basic level of study content. The results are analysed based on their skills, individual's method of learning and time constraints.

Keywords E-learning · Adaptive learning · Real time content · Personalised learning · Skill test · Navies Bayes · Behaviour test

1 Introduction

Web-based learning is adopted these days as another alternative to interactive education. Indeed, its use increases in a direct extent with the increase in the number of students. This has made educators exert a considerable measure of effort to help the learners to get interactive content that is loaded with multimedia as it has been proven that it significantly affects the process of learning. The effect of blogs and wikis has likewise been enquired on learners' collaboration and reflection, and it was reported that they both have a positive effect.

The twenty-first century has seen quick progress with so many things as the Internet and online learning. The increased utilization of e-learning among educational institutions has led to several variations in educational strategies. As indicated by reports, there has been a rise of around 12–14 percent every year in enrolment for online learning over a 5 years period: 2004–2009 after secondary education (Mobasher and Munindar 2004).

Fusing innovation in the learning procedure does not ensure motivated learners. Online guidance has brought about the student–teacher relationship ending up less interactive. Learning management system (LMS) is programming applications that include learning and teaching online tools. Numerous advanced education organizations have executed them to oversee online learning and teaching by offering guidance to staff and students to enhance the speed and viability of educational procedures and correspondence among students and faculty and students. As an ever-increasing number of technological tools wind up accessible for online education, interest keeps on expanding among teachers and different experts in the utilization of these tools in online courses (Boticario and Santos 2006).

One key inquiry to be addressed is the manner by which to build LMS that help the user-focused situation. Most courses on current LMS barely offer any information about

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which didactical techniques and models they utilize. To the extent adaptation is concerned, they provide predefined settings for a specific course that end up being the result of extensive customizations. In any case, if the client is central, courses are not anymore the key issue yet a stable situation where every client fulfills a specific arrangement of learning objectives. The issue surpasses the constrained situation of the current course and learners, their necessities, foundations, learning styles and watched behavior when confronting elective learning circumstances progress toward becoming relevant. This likewise suggests those learning circumstances must be unequivocally overseen all through various courses. Hence, it is expected to think about two kinds of situations, i.e., (1) predefined rules to oversee predicted circumstances and (2) dynamic reactions created with the data gathered from users' cooperations by modeling distinctive components associated with the learning procedure (learners, learning material, LMS administrations, and so forth.) and applying a few machine learning (Paramythis and Loidl-Reisinger 2003) and filtering systems (Picar 2003).

1.1 Our contribution

From the technological perspective, in the proposed work, a flexible, and extendable architecture based on Java technologies has been developed. The following contributions were accomplished in the work as follows:

- The proposed method will test the skills of the students and fetch them with the learning materials based on their evaluation in their skill test.
- The students are made flexible to learn by providing materials related to their chosen programming language on the basis of three categories like basic, normal and advanced.
- After evaluation, the personalized database with the help of ALMS offers the materials in the form of audio, video, pdf, ppt, and doc.
- The user can choose their mode of learning according to their capability. These processes collectively are done by Personalized Page Rank algorithm.
- The Navies Bayes classifier was included in the system to classify the learners based on the performance of the learners into high, medium and low category.

2 Literature review

2.1 User experience in e-learning

The novelty and developing accessibility of computers have allowed instructors to more cautious structure on how to teach. (Paul and Soukup 2011). M. Samir Abou El-Seoud et al., in their examination study examined that the utilization of natural highlights of e-learning expanded the motivation of the students for the learning procedure (Edmundson 2007). For example, an open source, Moodle e-learning application, was executed at numerous Egyptian universities. Moodle was utilized as a guide to convey e-content and to give different conceivable outcomes to execute asynchronous e-learning modules (Paul and Soukup 2011). Saromporn Charoenpit and Michiko Ohkura proposed an e-learning system configuration by learning management system (LMS) that centers around full of emotion perspectives utilizing feeling recognition technologies from biological signs to quantify, identify, and break down user emotions. They planned this to supplement the adequacy of e-learning (El-Seoud et al. 2014).

2.2 User flexibility and adaptability in e-learning

Chen et al. (2017) built up an innovative attention aware system (AAS) for exactly assessing the students' attention based on EEG signals. The proposed model was integrated into a video address labelling system for enabling the students to observe their very own low attention times while viewing an address of video. The outcomes exhibited that the proposed AAS practicality in serving online teachers in evaluating the students attention to upgrade their execution in online learning (Begam and Ganapathy 2016).

Chen, C. M et al., built up a unique attention observing and alarm mechanism (AMAM) through the brainwave signals to improve execution of learning by means of checking the attention condition of each and every learners thereby helping online teaching collaborators or educators to improve the managed learners attention levels through states of low-attention as they perform exercises of online synchronous support (Chen and Wang 2018) Yu-Chen Kuo et al., explored the impacts of a brainwave signal-based attention promoting mechanism on college students' learning accomplishments and learning states of mind in an English listening course. A semi trial configuration was directed to gather the learners' attention levels, learning accomplishment, learning attitudes, and helpfulness. The students' learning attention states were observed by means of an EEG sensor, and learning support was given when their attention levels faded (Mahboob et al. 2016).

Ling Wang et al., proposed another enhanced improved adaptive human learning optimization algorithm (IAHLO) in which a novel adaptive methodology was produced to powerfully tune the control parameter of the random learning operator with the goal that IAHLO can productively attach the linkage toward the start of cycle, build up the assorted variety at the center of searching procedure to investigate the solution space, and play out the exact local search toward the finish of inquiry to discover the optima (Wang et al. 2018).

3 Problem statement

Many researchers had carried out various experiments with several algorithms and mechanism to apprehend the behaviour of the student adaptability in e-learning. Most of them revolved around the attention of the students towards the e-learning and reported that the students lose their attention as the time goes in the learning. But none given the detailed study of the students based on their individual skill set, which is an important parameter to be considered in evaluating the student in the e-learning process. Hence for the present study the problem statement is:

> To identify the skill set of the student and develop the learning management system for effective e-learning environment.

4 Benefits of ALMS

For attaining the major goal of our work we had adopted the ALMS because of its following benefits.

4.1 Flexible

By implementing adaptive technologies, content are generated in numerous formats, for example, attachments, clips of videos, sound, and so forth. Persons have typical learning styles; some can learn well by verdicting out on subjects, some may watch videos, and others may listen. These typical learning styles suit various students. The ability to blend and match the suited content from various learning styles guarantees that all learners are protected in amid the procedure of learning (Charoenpit and Ohkura 2013).

Moreover, through adaptive technologies of learning, learners' responses can be separated gradually, and the assistance can be in balanced manner. With the practice, all students can work at own pace to achieve the most perfect academic result (Ennouamani and Mahani 2017).

4.2 Engaging

Adaptive learning takes into account exhibiting information as interactive exercises and tutorials, which make students anxious to learn. Understudy commitment will, in general, be advanced when exploiting adaptive learning technologies as students are combining with exercises of learning that are presented at the right time and for the precise reason. Besides, finding the correct solutions encourages and needs learners to ensue with the material, in achieving higher course rates completion.

4.3 Efficient

Adaptive learning methods exploit complete analytics of data and reports to express learning gaps among class, authorizing instructors to modify discourses to discourse the shortcoming or see where exercises can be made better. Then again, this likewise enables educators to spare time by not concentrating too intensely on regions where learners are as of now capable.

4.4 Behavioural learning

Behavioural Learning is significant as long as it is important to know, how people learn and what are all the factors influencing the learning style of the learner. It also helps in measuring a person's learnability. Behavioural study is thereby very influential in studying the psychology of the learner like what motivates the learner, what impacts his study and how well he can do when no environmental disturbances caused. In behavioural computer based study, learner's information is gathered by tracking his/her behaviour pattern while using a system. The learning model can be updated based on the preferred learning content, time spent on learning that content and answers obtained from questions and tests.

4.5 Reinforcement learning

Reinforcement learning algorithm plays an important role in getting back the response from the learner thereby refining the dynamic content. Madani et al. (2019) describes feedback is necessary to improvise the learning system and to analyse the learning capability of the learner. Herein the positive reinforcement, the learner would be given something when something happens. In negative reinforcement, something is taken out from the learner when something happens. In this way positive and negative reinforcement can both be used to either encourage or discourage an activity.

5 Smart skill test based Adaptive Learning Management System (ALMS)

5.1 Authentication of user in e-learning

Authentication is very pivotal in e-learning since information regarding the users must be secured. Security is an imperative issue in the real educational context where e-learning increases in fame and more and more people are taking online courses. The e-learning stages are today generation systems that need to be secured. To achieve a decent

level of security, there are numerous vital elements that must be taken into record: authentication, access control, and data integrity.

5.1.1 Database security

Database security concerns the utilization of an expansive range of information security controls to protect databases, potentially including the data, the database applications or stored capacities, the database systems, the database servers and the related network links against compromises of their confidentiality, integrity, and accessibility. Personalized cloud backup which keeps saving all completed learned content helps improving the learner's study track. Learning time, learnability, desired mode of learning element, behavioural changes of the learner can be tracked and deeply analysed and hence this customized data helps to improvise the progress of the learner.

5.1.2 E-learning resources

Database is made secured from file corruption, data loss, and authorized access. Learning resources are secured from cyber-attacks, malware, virus, etc. It must be accessible by the authentic user who is entitled to participate or access the learning resources.

5.1.3 Secured access

This means the e-learning system ought to have a solid authentication mechanism. It has a log-in system with a secret key where just the true user is just allowed to use the system, or just the person who is enrolled are permitted. Thereby, the fake user can be avoided. This is a very imperative requirement in the e-learning system.

5.1.4 Evaluation reports integrity, authenticity and confidentiality

The evaluation is incorporated with integrity and that the Evaluation Records of the Skill Test are made authentic. Evaluation Reports are kept confidential just to the true learner and can't be viewed by others (Nadire and Ala'a 2009).

5.2 User information security

Learners Profile ought to likewise be secured. Secured access is necessary to verify the user. This is to prove the identity of the user against impersonation or pretention. Along these lines, just the true user can participate (Fig. 1).

5.3 Skill-based e-learning environment

Based on the evaluation reports of the individuals, e-learning materials are provided. They are categorized into three levels namely basic, normal and advanced (Fig. 2).

5.3.1 Evaluation plan

Skill test consists of five questions. Each question carries 5 marks. The total marks attained by the user out of 25 marks will be automatically converted to 100 marks. The splitting of e-learning material categories will be done as in the conditions given below.

- If the mark is greater than or equal to 80, then the advanced level of materials is provided.
- If the mark is between 40 and 79, then a moderate level of materials is provided.
- If the mark is less than 40, then the basic level of materials is provided.

This process is illustrated as follows (Figs. 3, 4).

Illustration 1 Person A logs into the portal and enters his username and password. After logging in, he selects his preferable programming language (C programming) among n number of languages displayed. After choosing the language (C programming), the portal requests him to attend the skill test which incorporates questions based on the language chosen (C programming) by him. Five questions are displayed on the screen. He answers the entire question.

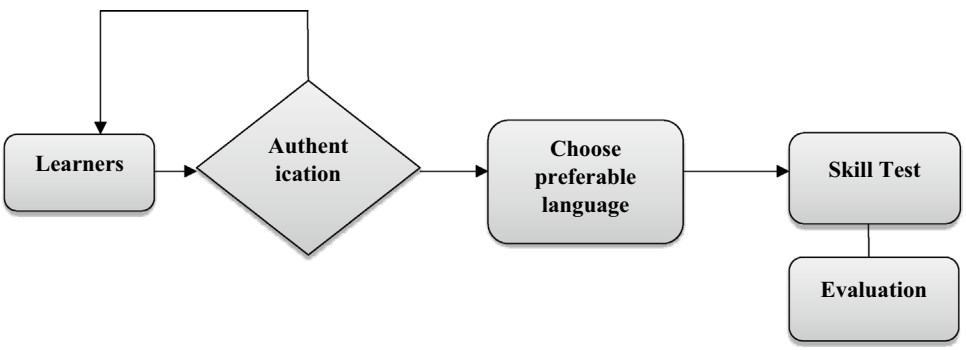


Fig. 1 Flowchart of authentication of users

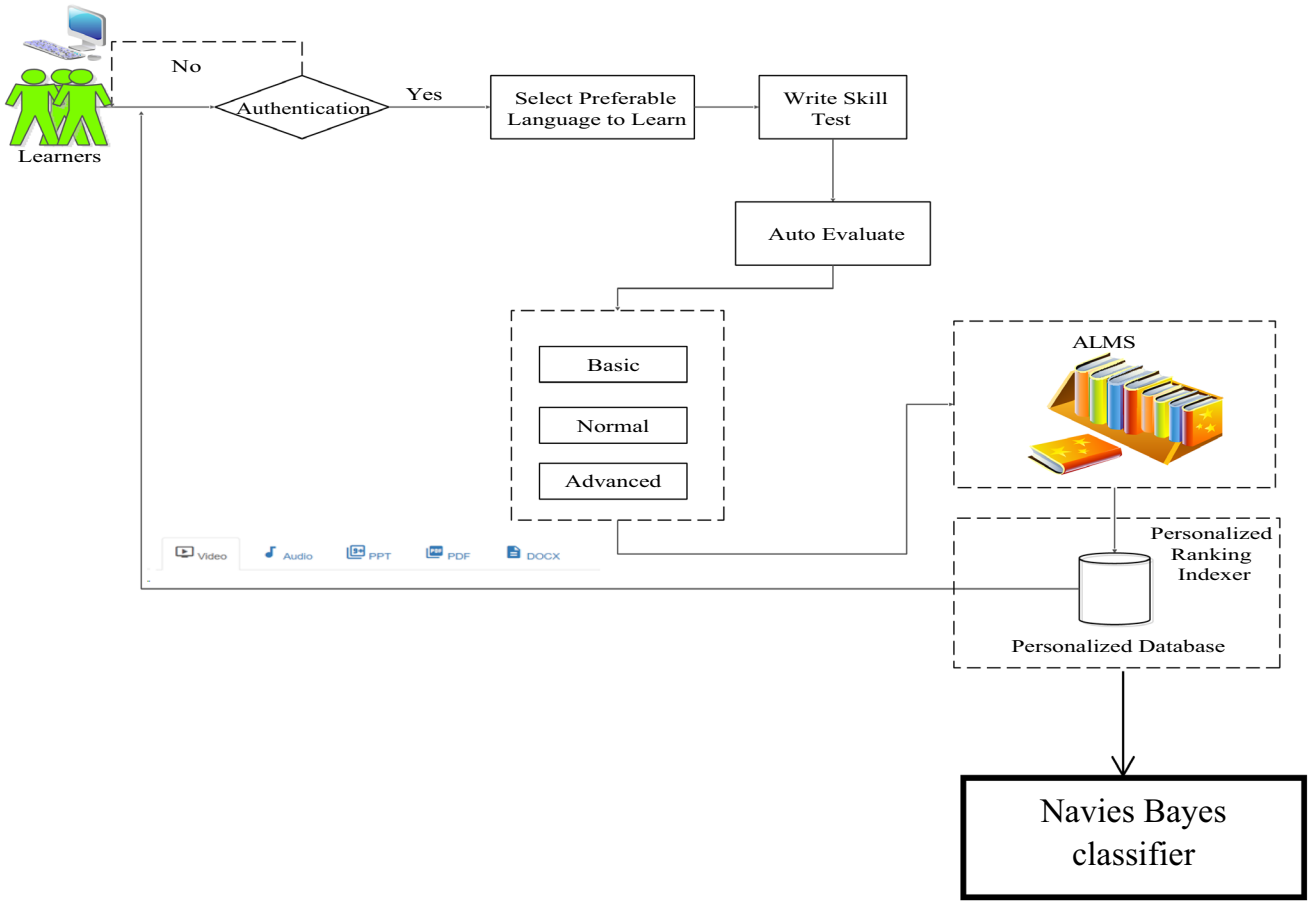


Fig. 2 Flow chart of Proposed Skill test based ALMS

After auto-evaluation, the mark attained by him is 60 that is he answered only 3 question correctly. Now the personalized database with the ALMS fetches the user with a moderate level of materials.

Illustration 2 Person B logs into the portal and takes the skill test in Java Programming. He attains 100 marks which means he has answered all the questions correctly. Now he will be provided with the advanced level of materials in Java for e-learning.

Basic Basic materials include programming language tutorials from basic concepts. Beginners will be easily filtered out from the skill test taken by them. So, this basic level of materials will be used to build a strong beginning about the concerned language. This also helps the students to score high marks thereby undertaking the moderate level of materials.

Moderate Moderate level of materials is mainly for students who know all the concepts of a particular programming language but somehow lagging in programming skill or who do know how to apply the concepts in real time. Moderate understandable tutorials are included in this level of material.

Advanced Advanced levels of materials are mostly preferred to experts in programming.

Advanced level of tutorials and exercises are incorporated. That is tutorials with more test cases are included.

In this system, the initial questionnaire is manually selected with the help of experts in particular subject. They create a list of evaluation questions which could be answered only when the learner is really familiar with the subject. It is designed in such a way that the depth of understanding a subject is technically questioned. Based on the basic education detail of the learner provided, the list of questions will be displayed. For example, if a high school student searches for studying Python course, our questionnaire will first display the beginner level list of questions. If that student is capable of answering almost all questions, it displays the middle level of questions and so on. These questions will be periodically updated with the help of subject experts. But in future, this could be designed like automatically selected by the use of advanced expert systems thus making the learning model fully automated.

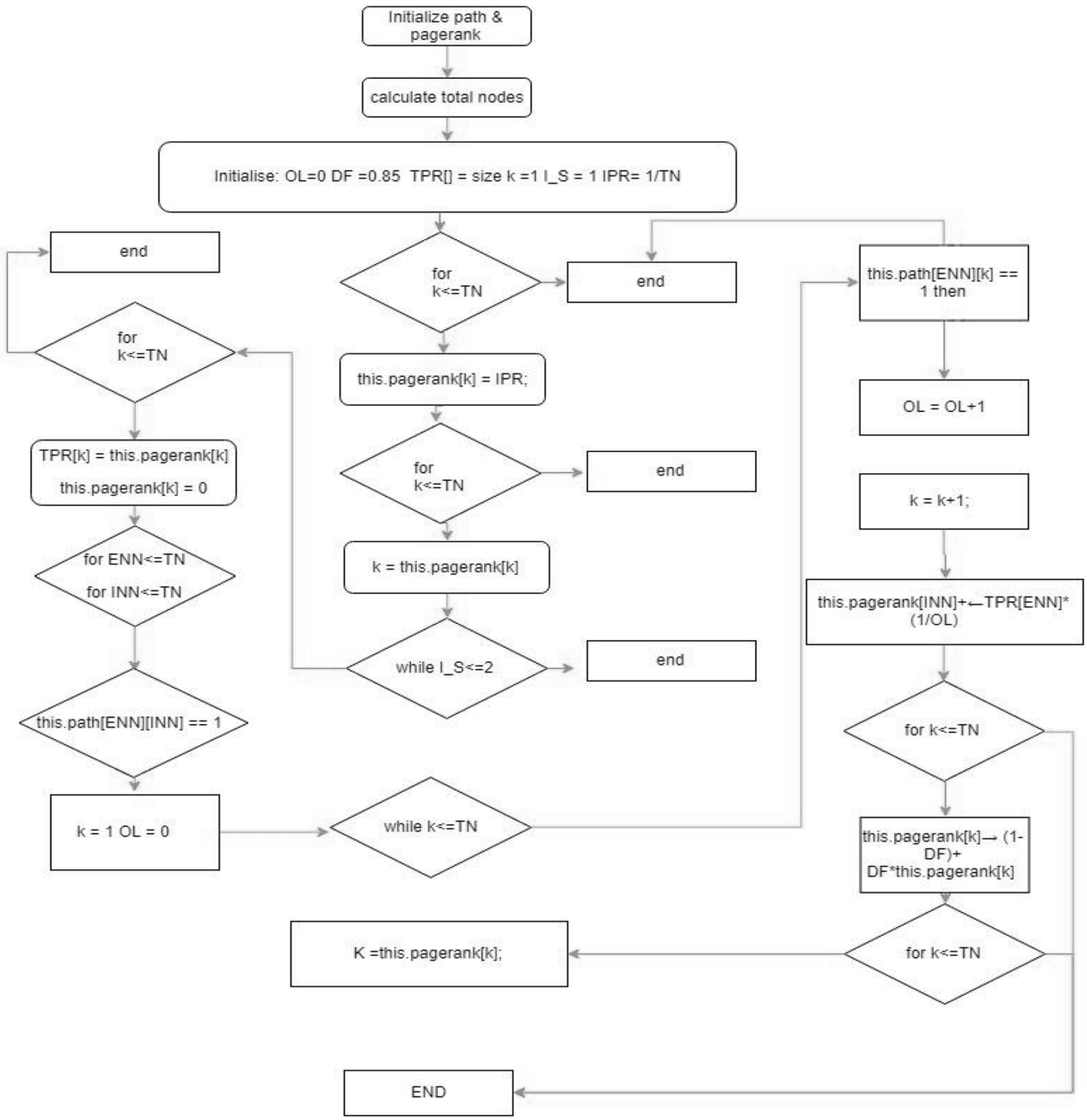


Fig. 3 PPR algorithm

6 Adaptive Learning Management System

Adaptive Learning Management System (ALMS) is the one which is more flexible and interactive and considers learners centric teaching methodologies. In ALMS, learning ways are provided consequently. ALMS manages to learn ways adapted to each user, screen user activities, interpret those utilizing specific models, infer user needs and preferences and exploit user and domain knowledge to powerfully facilitate the learning procedure. Learning style or learning way ought to be considered in any ALMS to achieve superior and better feedback. Learners with various needs or learning ways ought to be identified based on their behavior, activities, and interactions with the system and offer e-learning agenda or sequence of e-learning services (e-learning stream) based on their way of learning and capability (Begam and Ganapathy 2016).

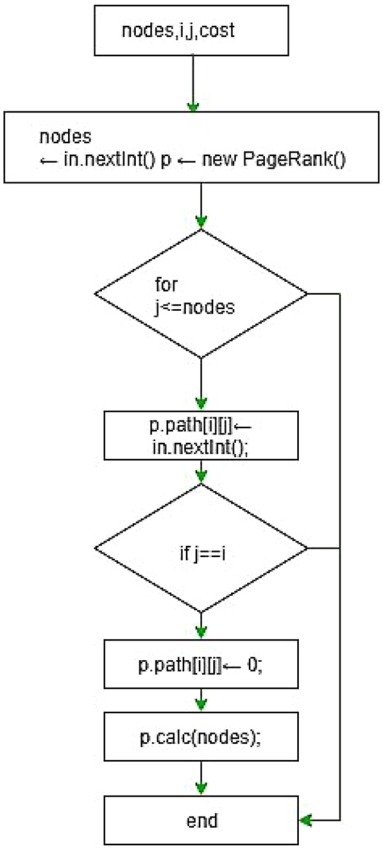


Fig. 4 PR test. Where OL = OutgoingLinks; DF = DampingFactor; TPR = TempPageRank; I_S = ITERATION_STEP; IPR = InitialPageRank; TN = totalNodes; INN = InternalNodeNumber; ENN = ExternalNodeNumber

With the end goal to motivate, encourage, and inspire learners, their environment is made personalized and adaptable (Boticario and Santos 2006). The mentioned two words are emphatically connected: adaptation relies on personalization. Adaptive learning enables the learner to access the most associating, interesting and challenging learning activities, and to abstain from learning material already acquired. Adaptation and Personalization are feasible via ALMS.

7 Personalized Page Rank (PPR) algorithm

The Personalized Page Rank (PPR)—is an efficient Page Ranker. It is purely working based on user interest and language with skill. Personalized Page Rank (PPR) algorithm is used for determining the personalized scores of the individual result. Page Ranking algorithm evaluates the importance of every web page and gives a numerical value of importance with the scale of 0 to10, say 10 for highly important web page content and 0 being less important. This level 0 web page results will be shown at the last pages of search results. In our work, we employ Personalised Page Ranking algorithm where we make use of that level 10 range of web pages. These rankings help the search mechanism to determine the most relevant search result for a particular query. Re-ranking the links is also possible with our PPR algorithm since we get feedback from the learner after studying the content of that particular web page hence modifying the link weightage. Jain and Gupta (2019) explains a new machine learning based approach for phishing detection using hyperlinks information. This helps in removing the phishing sites from the optimized search.

Using the PPR algorithm, the search optimization is achieved to a greater extent like re-ranking the page links which helps to exclude the broken links, ad based web pages, spam content and out dated pages. The continuous re-ranking and updating of page links helps to make the learning system more reliable.

The PPR algorithm is given as follows:

The Navies Bayes classifier was employed to classify the data on skill test result. Initially a portion of data was clustered i.e. 70% was fed into Navies Bayes to train them. After training, the complete clustered dataset was provided for testing the system. Finally, the classification of the student based on the skill test score criteria was obtained at three levels as high, medium and low.

8 E-learning elements

Different technologies are used to facilitate e-learning. The personalized database provides e-learning materials in the accompanying formats:

Audio One of the great strengths of e-learning was it allows students to maintain thier speed. Convenient readers comprehend and recall text by improving their reading speed. They reflect, repeat, pause, and skip to digest. Even employing two fingers on the back and pause catches, this is considerably tougher to govern with audio. Along these lines, they won't be able to avoid any concepts (El-Seoud et al. 2014).

Video Some people can consume data from various progresses, including sound-related, visual, kinaesthetic and written. Some need a visual mix of and sound-based guidance, others learn superiorly at the time of reading, and thereafter, there are persons who were more active in the process of learning. Currently, the greatest thing on video is that it includes elements from these learning ways in a distinct e-tool. This marks video one of the greatest engaging elements of available e-learning.

PDF The texts which are read stores in memory rapidly by human vision and observation. On the chance that one needs to read the sentence once more, then it should be possible easier just by learning utilizing pdf. Searching

for a specific concept or subject should likewise be possible utilizing pdf. One can likewise highlight or mark the very important text for further usage to learn or for further examinations.

PPT To positively use PowerPoint for speedy e-learning, two aspects are essential:

- Rethink in which way you can utilize PowerPoint. Numerous people approach it from a mind-set of linear presentation, and construct slides the similar way they could for presentation in face-to-face which do not work for e-learning.
- Learn to custom PowerPoint's structures. Once knowing the available superficial elements in PowerPoint, one can see it's additionally adequate for constructing great e-learning. From numerous perspectives, it's the perfect choice as it provides a speed blend, cost saving, and ease-of-use.

Doc Using doc files for e-learning possess the same benefits as pdf except in different format.

9 Results and discussion

The results are examined by scores obtained and the e-learning material given to the learners. About 55% of the users obtained average mark and were provided with the moderate level of materials, 20% of the users were provided with the advanced level of materials and 25% of the users were offered with basic level of materials.

In the adaptive e-learning portal, the questions of the skill test are shown in Fig. 5. The user can choose one of the options in every question. The auto-evaluation is done. The evaluation is considered for further analysis (Fig. 6).

Personalized database fetches the user with e-learning materials in one form among video, audio, pdf, PPT and doc as shown in Fig. 7 given below. The tutorials regarding the concept are displayed. The user can choose the topic which they need, or they can learn in the order of topics given. The same content of materials is given in different formats thereby making the learners flexible to learn the concepts in a shorter period.

Analysis has been done to examine the most used mode of e-learning. From the analysis, it has been found that 40%

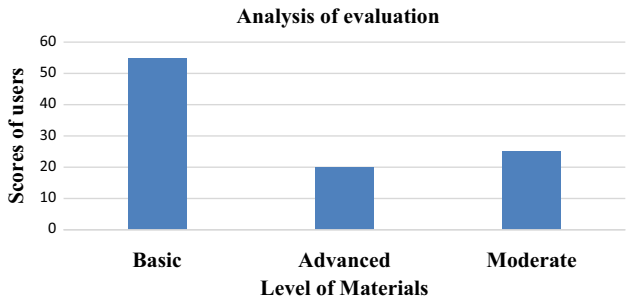


Fig. 6 Analysis of evaluation report

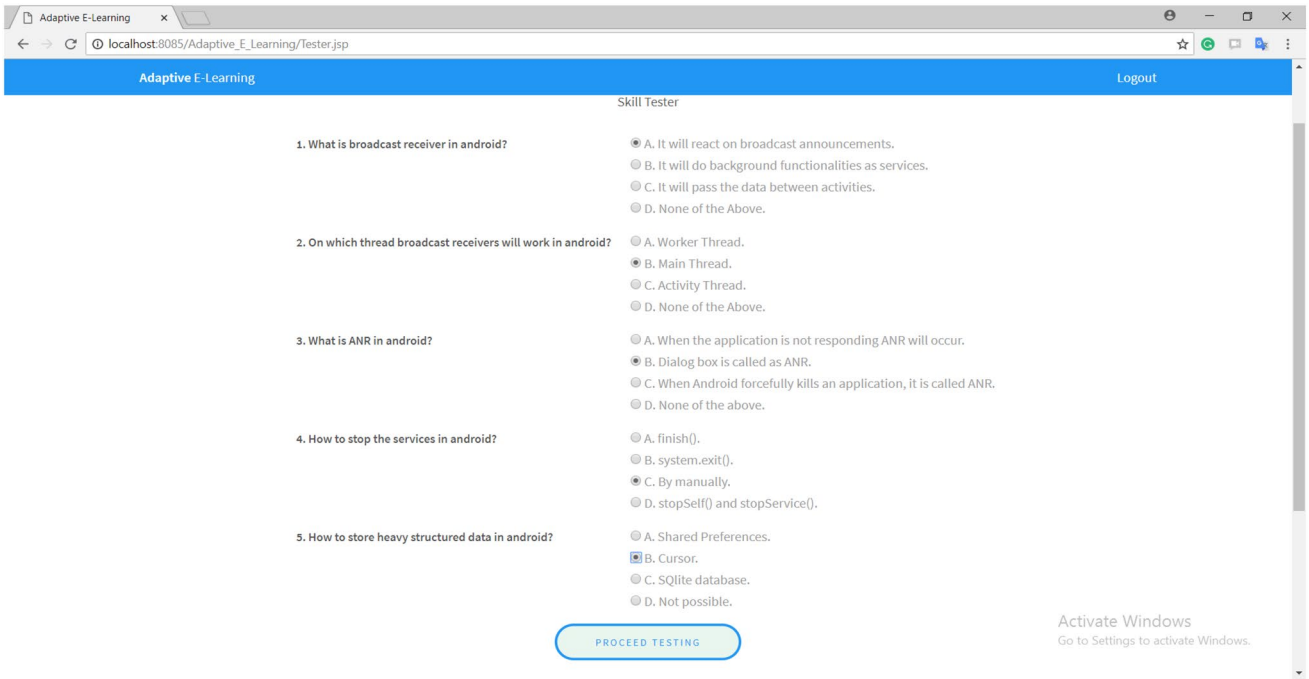


Fig. 5 Skill test undertaken by the user

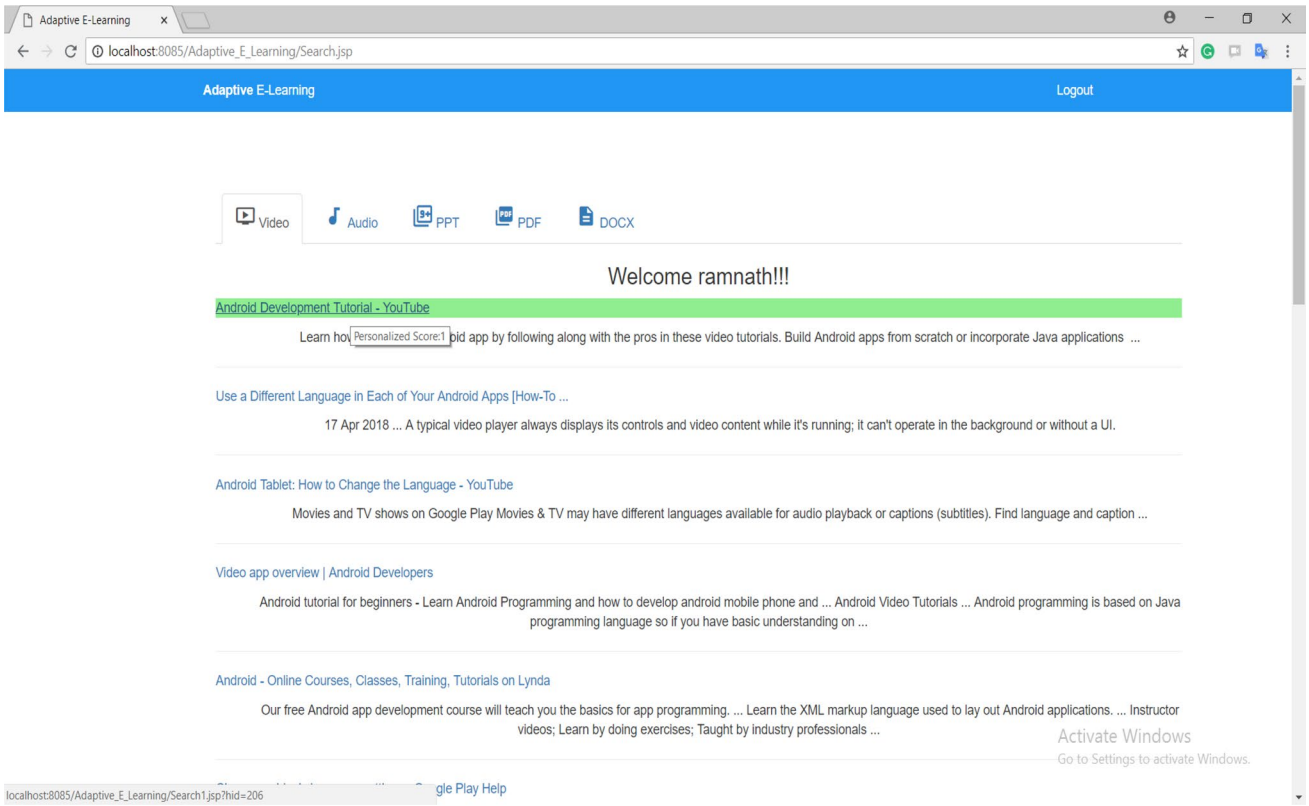
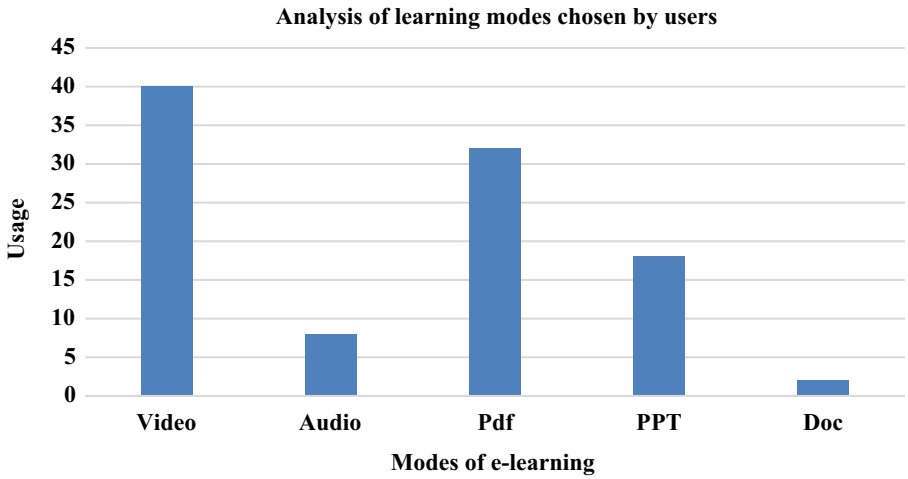


Fig. 7 Types of material provided to the user

Fig. 8 Analysis of modes of learning



used video e-learning, 8% used audio based e-learning, 32% used pdf based e-learning, 18% used PPT based e-learning, and 2% used doc based e-learning. Users choose video as a mode of learning mostly compared to all other modes. The results of analysis are shown in Fig. 8 below.

From Table 1, it has been identified that way of learning using video is widely utilized by basic and advanced e-learning students. Audio is perceived by only basic e-learning students. The PDF and PPT are used by basic and moderate

Table 1 Table for analysis of skill test

Modes of e-learning	User's prefer ability in percentage	Materials offered
Video	40	Basic, Advanced
Audio	8	Basic
PDF	32	Basic, Moderate
PPT	18	Basic, Moderate
Doc	2	Moderate

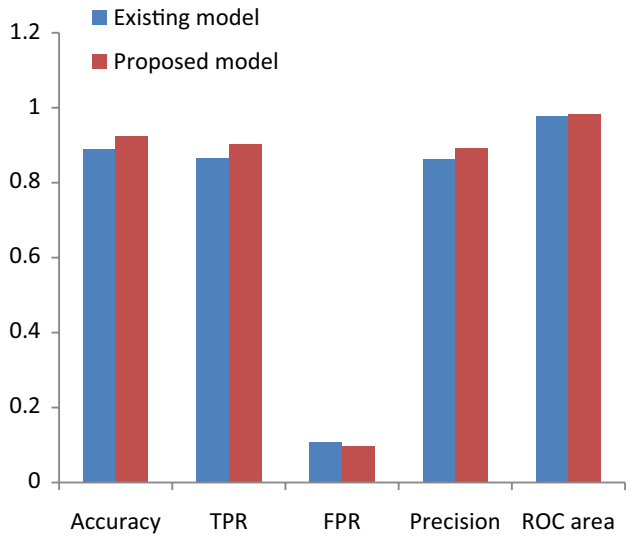


Fig. 9 Comparison of performance analysis over the proposed and existing models

Table 2 Performance of the existing and proposed model

Parameters	Existing model	Proposed model
Accuracy	0.8906	0.9245
TPR	0.867	0.903
FPR	0.109	0.096
Precision	0.863	0.892
ROC area	0.978	0.984

e-learning students. Doc is used rarely by moderate e-learning individuals. Thus, the behaviour of students in e-learning is studied, and they are provided with the efficient and needed materials according to their skills.

The performance of the Navies Bayes on classifying the students based on the obtained results from the skill test was analysed and the performance metrics was given below in Fig. 9. The accuracy of the proposed classification based on the criteria score attained the values of 92.45% over the existing model with 89.06% accuracy (Table 2).

The true positive and the false positive rate are obtained as 0.903 and 0.096 which was efficient than the existing model (Mahboob et al. 2016). Similarly the value on precision and the ROC area was higher than the proposed existing model.

10 Conclusion

The proposed design of the e-learning system focused on Skill Test based adaptive learning aspects. Using Skill Test detection technologies from e-learning, the skills evolved during the learning process has been explored and how skill-based feedback could be employed to progress experiences of learning were identified. Learners on their own can express the optimistic and adverse skills that significantly affect their adaptive learning in e-learning environment. The portal is found be user-friendly, flexible, and skill-based e-learning platform. Analysis of the students' evaluation reports and their modes of e-learning have been studied.

As a future part of work, more graphical user interface can be designed and extended with multiple functionalities as per requirement. Adaptive e-learning skill test can be developed with more security without loss of students score report. The proposed system has its own limitation like every other one, say making the use of subject matter experts to frame the list of questionnaire, which is manual now. The evaluation questionnaire could be designed like, automatically selected by the use of advanced expert systems in future, thus making the learning model fully automated.

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