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RESEARCH ARTICLE

A Recommender System Method for Children's Education Using Mobile Technology

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ABSTRACT In the last decade, we have seen attention and scientific research in using technology, especially the mobile technology, in education. The critical effects of technology in child education are increasing motivation, the self-confidence of children and their group cooperation. The purpose of this research is to provide a child educational recommender system using mobile technology, which includes decision making and real-time monitoring of the educational status of each child, personalization of educational materials based on the educational status of each child, recommendation of educational materials based on the extent of their dissemination in the children's educational network, etc. In this research, the type of research based on the objective is applied research. The statistical population includes children between the ages of 8 and 10 years. The child's educational recommender system includes input, processing and output. The mobile technology was used to track each child's educational activity and educational status and turn them into input keywords of the recommender system. In the processing section, various matching functions are provided to match each child's detected educational status with the educational documents. Finally, in the output section, educational documents adapted to each child's needs are e-mailed to the mobile phone of the child's parents. Because children cannot recognize and express their educational needs, in the proposed recommender system, all phases, from the recognition of children's educational activity and diagnosis of the educational status of each child to the presentation of educational documents related to the diagnosed educational status, have been done automatically. The educational recommender system is simulated using NetLogo and R. Also, the implementation of the educational recommender system has been done on 36 children. According to the results, the educational recommender system was able to increase children's learning more than twice.

INDEX TERMS Child, dissemination of information, education, mobile, recommender system.

I. INTRODUCTION

The first foundation of children's character building and community building is in the early years of life. Therefore, both qualitatively and quantitatively, this period is of special importance. Education in the childhood stage has been considered a stage of education. In order for the child to be on the right educational path, his education should be started from childhood. The use of educational technologies in children's education can create diverse learning

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opportunities, and compared to traditional teacher-centered education, it has advantages such as immediate feedback, personalization of education, decision-making and real-time monitoring, increasing the scope of attention, motivation and interaction, which it contributes to the quality of children's education. Technology has been shown in studies to improve children's learning [1]. The purpose of this research is to use mobile technology in order to create a recommender system for child education. In this research and in the education discussion of children, we intend to provide an educational recommender system to send the most suitable educational materials according to the needs of children. Because the

users are children, they are unable to recognize their needs. Also, their educational needs change rapidly. In addition, it is necessary to decide the educational materials needed for each child according to the child's education status as soon as possible, personalize it for each child and then send it to the mobile phone of the child's parents. Therefore, using mobile technology, these educational needs are recognized and then automatically converted into keywords and entered into the recommender system. In this research, a recommender system has been presented according to the educational status of children, where all steps from recognition of children's educational activity and identifying the educational needs of children to sending related documents are done automatically. Therefore, the following points can be mentioned regarding the novelty of this research:

1. Usually, in previous studies, individual trainings have been used, and group trainings and the use of other children have not been considered to increase each other's motivation and learning, which this research tries to take into account.
2. In previous studies, no attention has been paid to the children's communication network and looking at the problem as finding children with influence in the network and charismatic to increase the motivation and level of education of other children. In this research, this issue will be addressed using network analysis.
3. Due to the large volume of information and the difficulty in choosing appropriate information, in previous studies, solutions to find the fastest method of identifying educational documents suitable for the child's educational status have not been considered. In the proposed recommender system, educational documents are automatically recommended based on the diagnosed educational status of the child.
4. It is difficult for the teacher to control children especially in educational activities due to their high mobility. In the proposed method, it is possible to extract the communication and education network, resulting from children's educational activity, automatically and without the need of teacher control.
5. In the proposed method, by using the science of network analysis, different educational status of children has been identified in order to strengthen the learning process in them.
6. In the proposed method, analysis of networks can be done in real-time while extracting networks, which can help the teacher identify the status of children in the shortest possible time, especially in networks with high nodes.
7. In the proposed method, it is possible for parents and teachers to choose the method of obtaining information (using social networks, email, mobile phone, etc.), the number of materials and documents, the author of materials, the time of publication of materials, etc., in order to increase ease and efficiency.
8. In the proposed method, attention has been paid to the way and how to allocate educational materials to

children, in order to increase its dissemination on the network.

9. In the proposed educational method, all steps from identifying the educational status of children to providing solutions are done automatically and in the shortest possible time, which will increase ease, accuracy and efficiency.

Also, the following cases and sections have been used in this research:

1. Using the mobile technology to extract the network of children's education.
2. Analysis of the network created to determine each child's educational status.
3. Decision-making and real-time monitoring regarding the educational status of each child.
4. Personalization of educational materials needed by each child according to the educational status of each child.
5. Recommending educational materials, taking into account the dissemination of information in the children's educational network.
6. Recommending educational materials needed by each child individually and personalized to the mobile phone of each child's parents.

In section 2, the necessary background regarding the tools is explained in following section. In section 3, related researches are stated and their weaknesses and limitations and the need to address this research are stated. In Section 4, the proposed educational recommender system is described. Then, in section 5, the results of the simulation and implementation of the educational recommender system are stated, and the results are discussed. Finally, in section 6, the conclusion is stated.

II. THEORETICAL FRAMEWORK

In this section, a brief explanation of the tools used in this research, including data dissemination and Bayesian networks has been discussed.

A. DATA DISSEMINATION

In this section, the dissemination of educational materials is considered. Different models can be considered for disseminating educational materials, which can be mentioned as threshold and cascade models. These models are explained in the following.

1) THRESHOLD MODEL

In the threshold model, a threshold is defined for the activation of each node as a result of being influenced by its neighbors. Each node will activate after receiving enough flips from its neighbors. In the subject under study, nodes are children, and activation is learning. How to determine the threshold of each node; there are different versions of this model. One of these models is the linear threshold model. In this model, each node v is affected by each neighboring node, such as w , to the extent of $b_{v,w}$. Also, for each node v in the network, a threshold θ_v is defined. This value represents

the minimum amount of influence the node or child v must receive from its neighbors to activate or successfully learn. For node v and its neighbors like w , node v becomes active if $\sum_{\text{activenighbors of } v} b_{v,w} \geq \theta_v$ [8].

Another threshold model is the maximum threshold model. In this model, a child learns the educational material when at least half of his neighbors have approached him and taught him this material. To define the maximum threshold model with the help of the linear threshold model, it is enough for both nodes v and w , $b_{v,w} = 1$, and also, the threshold limit of each node, like v is equal to $\theta_v = \text{degree}(v)/2$ be defined [9].

Another model is the small threshold model. In this model, the threshold of all nodes is chosen to be a constant and small value. So, for a node to be activated or, in other words, for a child to learn successfully, it is enough to teach him one of his neighbors. To define this model using the linear threshold model, $b_{v,w} = 1$ and $\theta_v = 1$ for both nodes, such as v and w [9].

2) CASCADE MODEL

Another diffusion model is the cascade model. The independent cascading model is the simplest cascading propagation model in which each active vertex is assigned a possibility to activate its neighbors. For example, the probability of learning child w , as a result of teaching child v , is $P_w(v)$. In this model, the activation of a node is independent of the history of previously received flips [10].

Although the independent cascade model is a simple and practical model, it is not a suitable model in many scenarios of real problems. Because in these environments, the history of flips and training received by a child will be effective in his final learning. In this way, another model of cascade diffusion has been introduced, which considers the system's history. This model is called the dependent cascade model. The diffusion process in this model is similar to the diffusion in the independent cascade model. But the activation probability of vertex w is the value of $P_w(v, S)$. S means the set that tried to activate w and failed. For example, children who tried to teach a common subject to child w were unsuccessful. In this way, the independent cascade model can be considered a special case of the dependent cascade model. It is sufficient to consider the activation probability $P_w(v, S) = P_w(v)$ for each set S of neighbors [10].

B. BAYES' THEOREM

After the data is obtained from the implementation of the proposed method, it can be modelled using Bayesian theory to calculate the efficiency of the proposed method. It is also possible to create a Bayesian classification using the training and test data obtained from the implementation of the proposed method to estimate the child's label using his previous records. Bayesian networks are one of the methods of uncertainty control in problems based on probability theory. Many intelligent systems need to answer requests that ask for the probability of an event based on several observations. In many cases, it is desirable to calculate the conditional probability of

an event given some observations. The probability of event x , provided that y exists, is equal to formula 1 [11].

$$P(x|y) = \frac{P(x \wedge y)}{P(y)} \quad (1)$$

By assuming dependence in the form of an acyclic-directed graph, we arrive at a model of distribution known as Bayesian networks. A Bayesian network is a directed graph whose vertices contain information about conditional probability values. More precisely, this network includes the following components and characteristics [11]:

1. A set of random variables form the set of graph vertices, which can be discrete or continuous.
2. A set of directed edges, if an edge is from vertex X to vertex Y , we call X the parent of Y .
3. Each node X_i has a conditional probability distribution $P(X_i|Parents(X_i))$ that numerically shows the influence of the parent nodes on this node.
4. The graph has no directed cycle; it is an acyclic-directed graph.

By using Bayesian theory, it is possible to estimate the class label probability of a sample of data. If C is the name of the attribute of a class with m distinct value in the training data set D , in order to estimate the label of a sample such as d , all conditional probabilities $P(C = c_i|d)$ are calculated, and the highest probability determines the class label d . If the data set D has n attributes, d can be expressed as formula 2 [12].

$$d = \langle A_1 = a_1, A_2 = a_2, \dots, A_n = a_n \rangle \quad (2)$$

Based on this, Bayes' law can be shown as formula 3 [12].

$$P(C = c_i|A_1 = a_1, \dots, A_n = a_n) = \frac{P(A_1 = a_1, \dots, A_n = a_n|C = c_i) \times P(C = c_i)}{P(A_1 = a_1, \dots, A_n = a_n)} \quad (3)$$

Formula 3 can be used to calculate the probability of class labels with each other, and the larger probability determines the class label. Because the purpose is to estimate the class label, it is possible to skip the calculation of the probability value $P(A_1 = a_1, \dots, A_n = a_n)$, which is the same for all classes and has no impact on decision-making [12].

III. RELATED WORKS

The objective of this section is to review the studies that has employed technology in the process of child education, especially mobile technology, to determine the scientific gap in this research area. At first, the research done will be discussed. Then, the challenges of the conducted research, as well as the solutions of the method presented in this research in solving these challenges are stated.

Kouhi and Rahmani designed and developed a mobile phone application called Triangular App (TriApp) to teach preschool children multiplication. This application uses the triple multiplication method, where three numbers (including two numbers and the product of these two numbers) are regarded a group. To assess the efficiency of TriApp, two groups of preschool children were examined in 10 days.

The results indicated 100% of the children who used TriApp could solve the questions correctly, and only 40-70% of the children who were trained through the multiplication table could respond the questions correctly. Also, 94% of children were pleased with the application, while only 60% were pleased with the multiplication table. This mobile application was created with the Java programming language, Eclipse IDE and SQLite database [13].

Wan Ahmad and Ahmad Harnaini have designed a mobile application for children's education. The purpose of this research is to investigate how an application, including educational games, can help attract students' interest in the subject of science. This application is developed using Ionic Framework, Angular 5, C#.NET and SQL Express. An interview and a usability test were conducted by school teachers and a group of 10-year-old students. The results showed that most students enjoy learning science using mobile phone software [14].

Li has investigated using games to teach serious topics such as mathematics to 7-8-year-old children. In this research, an exploratory experiment is explained to investigate the effect of different interaction techniques (digital touch screen interaction vs. tangible interaction in the real world) and various feedback methods in children's math education [15]. The results showed that the use of games with digital touch screen interaction could improve math education.

De la Guía et al. have used technology to enhance the child's motivation in the education process. The teacher can interact with students and the system in real real-time through with a platform (mobile smartphone, laptop, tablet, etc.). The teacher can send a real-time message based on student behavior to control, encourage participation, motivate, and promote students' cooperation. The system has been tested and has shown very positive results. This study was conducted in two classes in Spain, where 100% of students replied to the teacher's messages [16].

Zhamanov et al. have examined the classroom equipped with modern tools such as the Internet of Things and gamification. Then they implement these classes as an element of the Internet of Things for the learning process instead of traditional learning. The findings demonstrated that the modern classroom method outperforms the traditional classroom method, with nearly 20% higher average attendance, tests, laboratory work, midterm exams, and final exams [17].

Rahman and Bhuiyan have designed and built a prototype of a platform to analyses the signals related to children with special needs to understand the situation and problems of students and perform related operations for better learning students. In the proposed model, through wearable devices, including mobile phones and sensors, students' information is stored for further processing for machine learning, analysis and deeper understanding, discovering a good model or human-guided fuzzy logic model. Data from the sensors are sent to a central repository for collaborative study, and the data is used to promote further studies. Based on the data,

an expert system, fuzzy logic, neural network, and decision tree have been developed [18].

De la Guía et al. have presented an electronic book for children in the Internet of Things environment. Toy characters have been employed to encourage children to read the book more frequently. By approaching his favorite character in each part of the book story, the child can direct the story's progression with his favorite character. Toys (with NFC chips) and other NFC-enabled cards, such as subway cards, can be used to define fictional characters [19].

Pervez et al. discuss aspects of the Internet of Things that help modern-day educators and students in the learning process. For example, with sensors placed on students' foreheads, they can inform teachers about their learning styles and help them create curricula for those needs. Also, research results showed that linking social media such as Facebook and Twitter to students' accounts can help researchers to collect data and use them to design things that are more attractive to learners [20]. In the following, the challenges of the previous methods in child education and the proposed solutions to solve the challenges, are mentioned as the research's output.

- In previous research, recognition of children's educational activity and children's education network was not considered; in this research, this network was extracted using the mobile technology.
- In previous research, the analysis of children's education network and the identification of the educational status of each child separately has not been taken into account. However, in this research, this issue has been taken into account by analyzing the educational network.
- In previous research, personalization and recommendation of educational materials according to each child's condition have not been considered.
- In this research, a system for recommending educational materials according to the status of each child has been presented, which uses mobile technology.
- Children are unable to express their needs. Therefore, it is also necessary to consider decision-making and real-time monitoring for these people and send them the required materials as soon as possible. In this research, a recommender system has been presented that all processes from recognition of children's educational activity and detecting the educational status of each child, converting the status of children into keywords and sending educational materials specific to each child in a personalized and real-time and automatically using mobile technology will be done.

IV. MATERIALS AND METHODS

In this research, the type of research based on the purpose is applied research. The statistical population includes children between the ages of 5 and 8 years. The mobile technology is used to extract children's educational networks based on children's educational activities. After analyzing the created educational network, the educational status of each child is

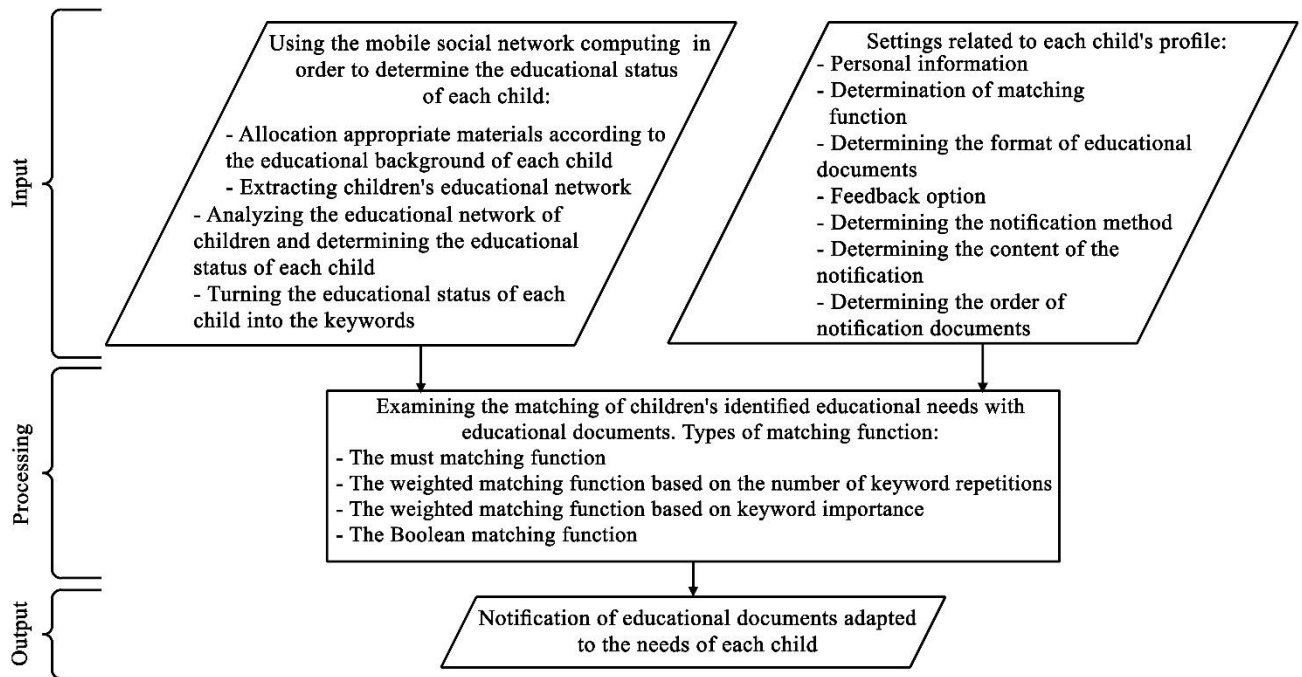


FIGURE 1. Input, processing and output parts of the children's educational recommender system.

determined. After automatically converting the educational status of children into keywords, the educational materials needed by each child have been recommended according to the educational status of that child. Mathematical modelling, including Bayesian networks, has been used to evaluate the proposed method's efficiency. The proposed method includes a recommender system that performs all phases, from detecting the educational status of each child to recommending personalized educational materials for each child automatically. The proposed educational recommender system includes input, processing and output phases, as shown in Figure 1.

A. THE INPUT PART OF THE EDUCATIONAL RECOMMENDER SYSTEM

1) USING THE MOBILE TECHNOLOGY TO RECOGNITION OF CHILDREN'S EDUCATIONAL ACTIVITY AND DETERMINE THE INPUT RELATED TO THE EDUCATIONAL STATUS OF EACH CHILD

In this section, the mobile technology been employed to extract children's educational networks and determine the educational status of each child as input to the recommender system. For this purpose, microcontroller and smart phone are used. The technical components are described in the following.

a: TECHNICAL COMPONENTS

i) NETWORK ENTITIES

Network entities are children.

ii) TOOLS

Microcontroller and smart phone are used. In card simulator mode, the user interacts with an NFC reader device to be able

to use his mobile phone as a smart card. The operating mode of the card simulator can enable a device with NFC capability to act like a contactless smart card. For example, children can use smartphones instead of smart cards to introduce and teach. Currently, the communication interfaces supported for the card emulation mode of operation are ISO/IEC 14443 Type A and Type B and FeliCa [21]. In Figure 2, an outline of this operational mode is shown.

iii) CONTENT

The content includes text, slides, videos and educational software.

iv) CONTENT STANDARD

The standard used in educational content is the SCORM standard.

b: EDUCATIONAL PROTOCOLS

i) CONTENT ALLOCATION AND TRAINING PROTOCOL

In this section, the allocation of educational materials that children should teach each other has been discussed. In allocating educational materials to each child, the child's educational background is considered. One subject may be a prerequisite for another subject. For example, one subject can be teaching addition and subtraction and another subject can be multiplication and division of numbers. The subject of addition and subtraction is a prerequisite for the subject of multiplication and division. For this purpose, the data structure of directed acyclic graph (DAG) as shown in Figure 3 should be considered for subjects.

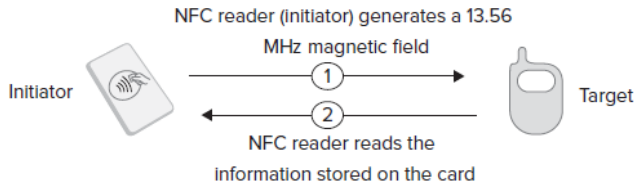


FIGURE 2. The operating mode of the card simulator using mobile [21].

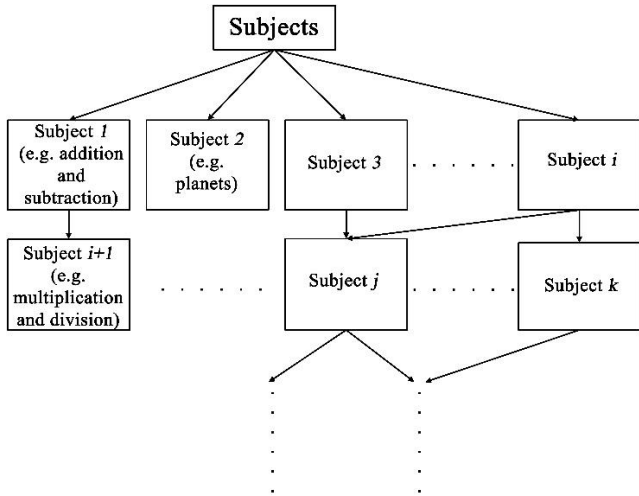


FIGURE 3. Data structure of subjects considering prerequisites of subjects.

In order to meet the prerequisites of educational subjects, labels are considered for subjects. The label is actually a number; But this number is a significant number that consists of several parts. The first section is the subject code of the educational material, and the following sections describe the section code, serial number, child number, parent number, and topological order number. For example, for the subject of animals, the section can include aquatics, birds, mammals, and reptiles, while mammals themselves can include sections of carnivores or herbivores, which is assigned them the codes. The total of codes makes up the label. Figure 4 shows the components of a label.

Figure 5 shows an example of a label with subject code 1 (e.g. animal subject), section code 2 (e.g. herbivores), topological order 7 with serial number, child number and parent number specified.

If we divide the educational material into sections and assign a label to each section, we will have a DAG, which is shown in Figure 6 for example with the subject of animals.

The thing that should be considered in allocating content to each child is that until the child has not learned the higher sections, sub-sections with more detailed content should not be assigned to him. For example, in the subject of animals, until the bird section has not been taught, more detailed material such as herbivorous or carnivorous bird animals’ section should not be assigned. For this purpose, the label assigned to each child are stored in the database. Then, using the code of the sections and the topological order, a decision is



FIGURE 4. Components of a label.

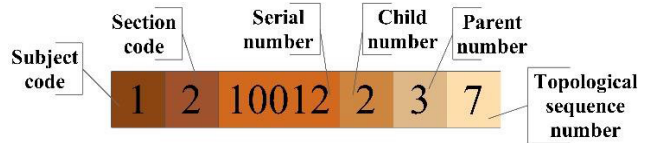


FIGURE 5. An example of a label.

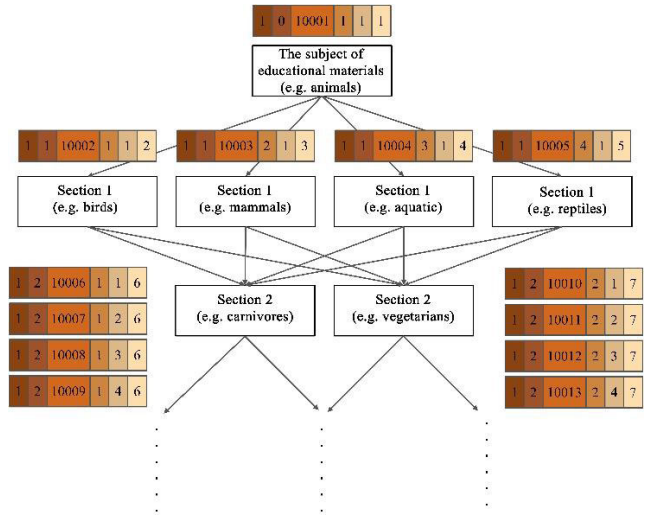


FIGURE 6. The DAG for dividing educational content into sections and assigning labels.

made regarding the assignment of an educational material to that child. Also, if a new section is added to a subject, using the following algorithm, the DAG data structure and labels can be updated. The new section that we intend to add to the DAG is assumed to be S_u .

As seen in Algorithm 1, by using the recursive function of Insertion, the new section S_u that we intend to insert into the DAG, moves to the lower levels of the DAG data structure as long as it is a subset of other sections. After inserting a new S_u section in DAG, components of labels including section code, child number, parent number and topological sequence number are updated.

ii) CONTENT EXCHANGE AND INTERACTION PROTOCOL

In this method, three types of microcontroller devices are used. The first device is for managing entry and exit to the classroom. The second device is related to the allocation of educational materials to students. The task of the third device is to manage the class and teach children. The arrangement of these devices is shown in Figure 7.

The steps of information exchange and education between children are described below:

Step 1. At this step, the children go to device number 1 (N1) with the smart phone of the card simulator, and by registering

Algorithm 1 The DAG Formation and Labels Updating

```

// The DAG formation //
1  Function: Insertion ( $S_u, root$ )
2  For each child  $v_i$  of the root of DAG do
3      If the  $S_u$  is a subset of the subject  $v_i$  do
4          Insertion ( $S_u, v_i$ )
5      End if
6  End for
7  Connect the edge of the root to the  $S_k$ 
8   $label_u[5] = label_{root}[4];$ 
9  For each child  $v_i$  of the root do
10     If the  $v_i$  is a subset of the  $S_u$  do
11         Delete edge from root to the  $v_i$ 
12         Connect the edge of the  $S_u$  to the  $v_i$ 
13          $label_i[5] = label_u[4];$ 
14     End if
15 End for
// The updating of topological sequence number //
16 Call DFS(DAG) to compute finishing times  $f[v]$  for each vertex  $v$ 
17 As each vertex is finished, insert it onto the stack
18  $j = 1;$ 
19 For each vertex in the stack do
20     Take  $S_u$  out of the stack
21      $label_u[6] = j;$ 
22      $j = j + 1;$ 
23 End for
    
```

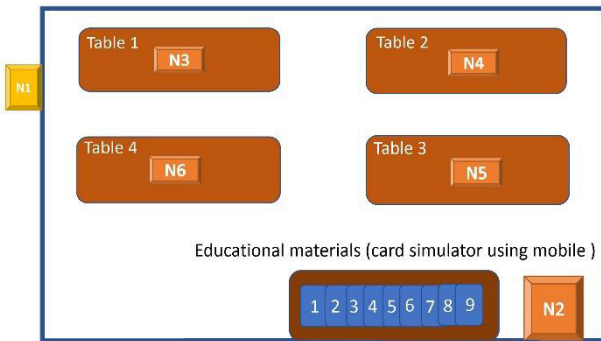


FIGURE 7. The arrangement of microcontroller devices and card simulators using smart phones.

the card in the device, the device shows whether the entered class is allowed to enter or not. If allowed, the device will open the door for children.

Step 2. At this step, children refer to device number 2 (N2), take the smart phone of the card simulator corresponding to their student numbers and register them in the device.

Step 3. At this step, the children who want to study together, choose the desired educational cards and go to one of the tables.

Step 4. At this step, the children who have gathered around the table for group study (for example, the table corresponding to device N3), by entering the simulated student cards with their smart phones, turn on the device and after entering all their cards, they press the green button. With this, the class begins.

Step 5. At this step, after confirming the device located on the table, the students register their desired educational card

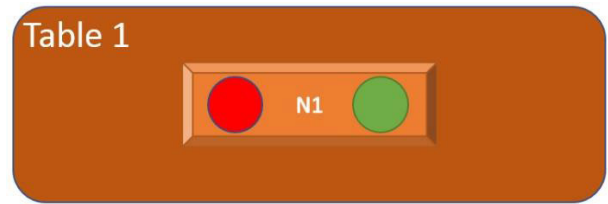


FIGURE 8. Announcing the end or cancellation of training with the device located on the table.

in the device to start training. In registering each educational card, using the ID cards registered for each child in step 4, the system checks whether other children gathered on the same table have passed the necessary educational prerequisites or not (This checking is possible by using the labels stored in the database related to the child that he has passed so far and checking the section code and topological order number.). If a child did not pass the necessary prerequisites, the system deletes it and the child must go to another table for education.

Step 6. At this step, children press the green button to announce the end of the training and press the red button to cancel the training. This device is shown in Figure 8.

Step 7. Steps 5 and 6 can be repeated with other training cards.

iii) PROTOCOL FOR THE FORMATION OF COMMUNICATION AND EDUCATION NETWORKS

In the designed educational protocol, each child who first registers his card in the device on the table will be the initiator of teaching other children. Therefore, in the educational network, a directional link will be drawn from him to other children. Also, according to the educational protocol, children can change their educational tables and teach each other educational materials. Therefore, a child can have different links to other children by using different tables.

Also, after registering the ID cards in the microcontroller, a link is created in the communication network between all the children sitting at the same table. In fact, they form a complete graph. Note that this complete graph is created for children sitting at the same table, not all children.

For example, suppose there are 6 children with ID cards 1 to 6, and the adjacency matrix related to their education and communication network is as follows. The adjacency matrix of the education network for table 1:

$$\begin{matrix} & \begin{matrix} \text{Child 1} \\ \text{Child 3} \\ \text{Child 5} \end{matrix} \\ \begin{matrix} \text{Child 1} \\ \text{Child 3} \\ \text{Child 5} \end{matrix} & \begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 0 \\ 1 & 1 & 0 \end{bmatrix} \end{matrix}$$

The adjacency matrix of the communication network for table 1:

$$\begin{matrix} & \begin{matrix} \text{Child 1} \\ \text{Child 3} \\ \text{Child 5} \end{matrix} \\ \begin{matrix} \text{Child 1} \\ \text{Child 3} \\ \text{Child 5} \end{matrix} & \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix} \end{matrix}$$

The adjacency matrix of the education network for table 2:

$$\begin{matrix} & \text{Child 3} & \text{Child 4} \\ \text{Child 3} & \begin{bmatrix} 0 & 1 \end{bmatrix} \\ \text{Child 4} & \begin{bmatrix} 0 & 0 \end{bmatrix} \end{matrix}$$

The adjacency matrix of the communication network for table 2:

$$\begin{matrix} & \text{Child 3} & \text{Child 4} \\ \text{Child 3} & \begin{bmatrix} 0 & 1 \end{bmatrix} \\ \text{Child 4} & \begin{bmatrix} 1 & 0 \end{bmatrix} \end{matrix}$$

Therefore, the adjacency matrix of the education network for all children will be equal to:

$$\begin{matrix} & \text{Child 1} & \text{Child 2} & \text{Child 3} & \text{Child 4} & \text{Child 5} & \text{Child 6} \\ \text{Child 1} & \begin{bmatrix} 0 & 0 & 1 & 0 & 1 & 0 \end{bmatrix} \\ \text{Child 2} & \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \\ \text{Child 3} & \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix} \\ \text{Child 4} & \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \\ \text{Child 5} & \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \\ \text{Child 6} & \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{matrix}$$

Also, the adjacency matrix of the communication network for all children will be equal to:

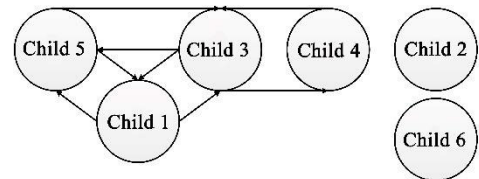
$$\begin{matrix} & \text{Child 1} & \text{Child 2} & \text{Child 3} & \text{Child 4} & \text{Child 5} & \text{Child 6} \\ \text{Child 1} & \begin{bmatrix} 0 & 0 & 1 & 0 & 1 & 0 \end{bmatrix} \\ \text{Child 2} & \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \\ \text{Child 3} & \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 \end{bmatrix} \\ \text{Child 4} & \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \\ \text{Child 5} & \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \\ \text{Child 6} & \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{matrix}$$

In this example, children 2 and 6 have no connection with other children and are isolated nodes. The communication and education network of this example is shown in Figure 9.

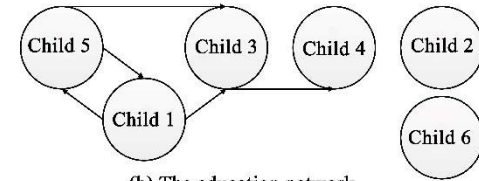
iv) PROTOCOL FOR REQUESTING ASSISTANCE IN RECEIVING TRAINING ON A SUBJECT

The children must learn the assigned items correctly and entirely in order to have successful teaching. In addition to educating parents and teachers, children can reinforce the educational materials assigned to them through smart bulletin boards or smart books. For this purpose, the following protocol is suggested:

1. Bulletin boards should be equipped with NFC tags.
2. Educational books should be equipped with NFC tags.
3. Using a mobile phone, the child should scan the section related to the content he needs in the bulletin boards and books.



(a) The communication network



(b) The education network

FIGURE 9. An example of communication and education network for six children.

4. Educational materials related to the part scanned by the child should be sent to his mobile phone and the child’s parents.

Figure 10 shows scanning required educational materials using wearable devices such as mobile smartphones from the smart bulletin board. This case can also be considered for books and create a smart educational book.

c: USING NETWORK ANALYSIS TO DIAGNOSE THE EDUCATIONAL STATUS OF EACH CHILD

In this section, the educational status of children is determined by analyzing the educational network form as a result of educational activity. For example, the nodes with highest in-degree are children who have successfully learn from other children, and their learning status is desirable. In order to determine the educational status of children, a threshold can be defined to check the links they have had in the education network. For example, the threshold set for the education network can be half of the maximum possible number of links of each node, and the nodes whose number of links is higher than this threshold can be determined as the desirable educational status. Also, the nodes whose number of links is less than the threshold are determined as weak educational status. The algorithm for determining the educational and communication status of children is described in the following.

According to the stated algorithm, in order to identify the child’s communication status with other children, the adjacency matrix of the communication network, represented by “CN”, is analyzed. For this purpose, the rows of the “CN” matrix, which show the child’s communication with other children, were examined. If the respective child’s communication with other children is less than half of the maximum possible communication, that child is diagnosed as having weak communication skills.

In the same way, the adjacency matrix of the education network, denoted by “EN”, is analyzed. Row *i* of the “EN”



FIGURE 10. Smart bulletin board using mobile technology.

matrix shows the teaching of child i to other children. In this section, a threshold called “Th [i]” is considered. This threshold represents the number of children that child i had the opportunity to teach, so that the prerequisites of other children are met. If the number of children taught by child i was less than this threshold, child i is identified as a weak educator in the teaching material assigned to him. Therefore, the educational materials assigned to child i and specified in the label (including subject code, section code, etc.) are converted into keywords. These keywords are the input of the educational recommender system, in order to search for documents related to these specified keywords.

In the same way, the columns of the adjacency matrix of the education network are checked in order to identify the status of children in learning. If the child i is found to be a weak learner, all educational materials that he did not succeed in learning will be converted into keywords.

2) SETTINGS RELATED TO EACH CHILD'S PROFILE

a: KEYWORDS SPECIFYING THE CHILD'S NEEDS

After the educational status and the type of need of each child have been recognized by the educational protocols described in the previous section, keywords should be created for that need. For example, if a child is diagnosed as a weak learner, keywords such as weak learner, identifying learning style to improve child learning, educational games to improve child learning, etc. should be created. These keywords are input to the recommender system.

b: PERSONAL INFORMATION

In this section of the profile, each child's personal information and the child's parents is received. Two modes for the user's personal information should be considered:

- Necessary Personal Information. Personal information whose entry is necessary to create a profile. Such as name, surname, address, and phone.
- Optional Personal Information. Information that is not necessary to enter and the profile is created without

Algorithm 2 Determining the Educational and Communication Status of Children

```

// The communication status //
1  Input: CN, EN, N, Th [N], Label [N];
   // CN: The adjacency matrix of communication network // EN:
   The adjacency matrix of education network // N: Number of
   children // Th [N]: Threshold //
2  Sum = 0;
3  For i=1:N do
4      For j=1:N do
5          Sum = Sum + CN [i][j];
6      End for
7      If Sum < N/2 do
8          Child [i] has weak communication skills.
9          Sum =0;
10     End if
11 End for
// The educational status // Checking the teaching status //
12 Sum = 0;
13 For i=1:N do
14     For j=1:N do
15         Sum = Sum + EN [i][j];
16     End for
17     If Sum < Th[i] do
18         Child [i] is a weak educator.
19         Keywords [i] = Label [i];
20         Sum = 0;
21     End if
22 End for
// The educational status // Checking the learning status //
23 Sum = 0;
24 For i=1:N do
25     For j=1:N do
26         Sum = Sum + EN [j][i];
27     End for
28     If Sum < Th[i] do
29         Child [i] is a weak learner.
30         For k=1:N do
31             If EN [k][i] == 0 then
32                 Keywords [i] = Keywords [i] + Label [k];
33             End if
34         End for
35     End if
36 End for

```

registering them. But entering this information into the system is useful in providing some features such as recognizing similar users and recommending a document if that document is among the interests of other similar users. This information can be things like a child's educational background, parents' occupation, child's age, child's gender, etc.

c: DETERMINATION OF MATCHING FUNCTION

There are various matching functions to match educational documents with the needs and educational status of the child, and the user should select the type of matching function should select the type of matching function should select the type of matching function. The recommender system processing section explains the types of matching functions and the description of each matching function.

d: DETERMINING THE FORMAT OF EDUCATIONAL DOCUMENTS

An option should be designed in the profile to select the document format (Word, PDF, Slide, etc.) so that the user

can express his favorite format. Of course, it is perfect to ask about the format for each document separately so that the user can decide on the type of format based on each document.

e: FEEDBACK OPTION

In order to provide better services and know the system's problems, it is necessary to receive the criticisms and issues faced by the users. By providing a possibility called feedback, users can express their opinions and problems. Two types of feedback need to be considered in the design of the proposed recommender system:

- Document Feedback. In this section, for each document that is notified to the user, an option for feedback related to that document should be prepared, and the user can express his opinion about that document. For example, things like the degree of relevance of the document to the child's educational status and his educational needs, problems with writing the document, etc., can be stated.
- General Feedback. In this section, the user expresses the recommender system's general feedback and his opinion on the entire system, including the relevance of the documents that have been notified to him so far, the number of notifications, system features, technical problems of the system, etc.

Feedback can be done in several ways:

- Giving a Score. In this case, the user expresses his opinion in the form of a score within the specified range; the higher the score, the more satisfied he is.
- Choosing an Option. The system can consider predetermined options, and the user can choose one of the options based on his opinion. The advantage of this method is that the system obtains the information it deems necessary and that the user may not pay attention to in providing feedback.
- Descriptively. In this case, the user expresses his opinion by typing. The problem with this method is the difficulty of analyzing it by a machine, and it is necessary to involve humans in extracting information.

In order to achieve the best result in the proposed recommender system, all of the above should be considered, and the user should fill in one, two or all of them based on his desire.

f: DETERMINING THE NOTIFICATION METHOD

Informing the user about finding the document he needs can be done in different ways, including:

- In the user profile
- Using e-mail
- Using a mobile phone (text, call, etc.)
- Through virtual networks (for example, Telegram, etc.)
- By post

g: DETERMINING THE CONTENT OF THE NOTIFICATION

In this section, it is determined what the notification to the user should include. In this regard, the following can be mentioned in the notification of each document to the user:

- The title of the document
- The title of the document and the author of the document
- Title, author, abstract and keywords of the document
- Title, author, abstract, keywords and table of contents of the document
- Title, author, abstract, keywords, table of contents and the first ten pages of the document

In this regard, the user must be the decision-maker and declare his desire for the received notification content by specifying it in his profile.

h: DETERMINING THE ORDER OF NOTIFICATION DOCUMENTS

The documents that are notified to the user can be prioritized based on various methods, some of which are:

- Degree of relevance
- Publication date
- Alphabetical title

B. PROCESSING SECTION OF EDUCATIONAL RECOMMENDER SYSTEM

1) MATCHING METHODS

The two main elements of the proposed recommender system include user interest profiles and specified references for each document. A graphical representation of recommender system parts (with the example of children's education) is shown in Figure 11, where dimensions and values are represented as brown and white nodes, respectively.

As stated in the educational protocols section, educational materials are assigned to each child in the form of a label (including subject code, department code, etc.). It was also stated that if a child is identified as a weak educator or learner, the labels convert to keywords. The keywords are actually the dimensions and values of the educational recommender system profile section shown in Figure 11. For example, if the subject assigned to child i is mathematics and the assigned section is addition and subtraction (specified by the label), and the child is a weak educator, the keywords will be math and addition and subtraction, which are actually the dimensions and values in the profile section of the educational recommender system. Therefore, all phases, from assigning educational materials and labels, recognizing the educational status of the child and converting the educational status into keywords, happen automatically and there is no need for manual classification.

After specifying the dimensions and values in the educational recommender system profile section, matching functions are used to check the similarity of these dimensions with the documents. The types of matching functions used for similarity detection are explained in the next section. In the

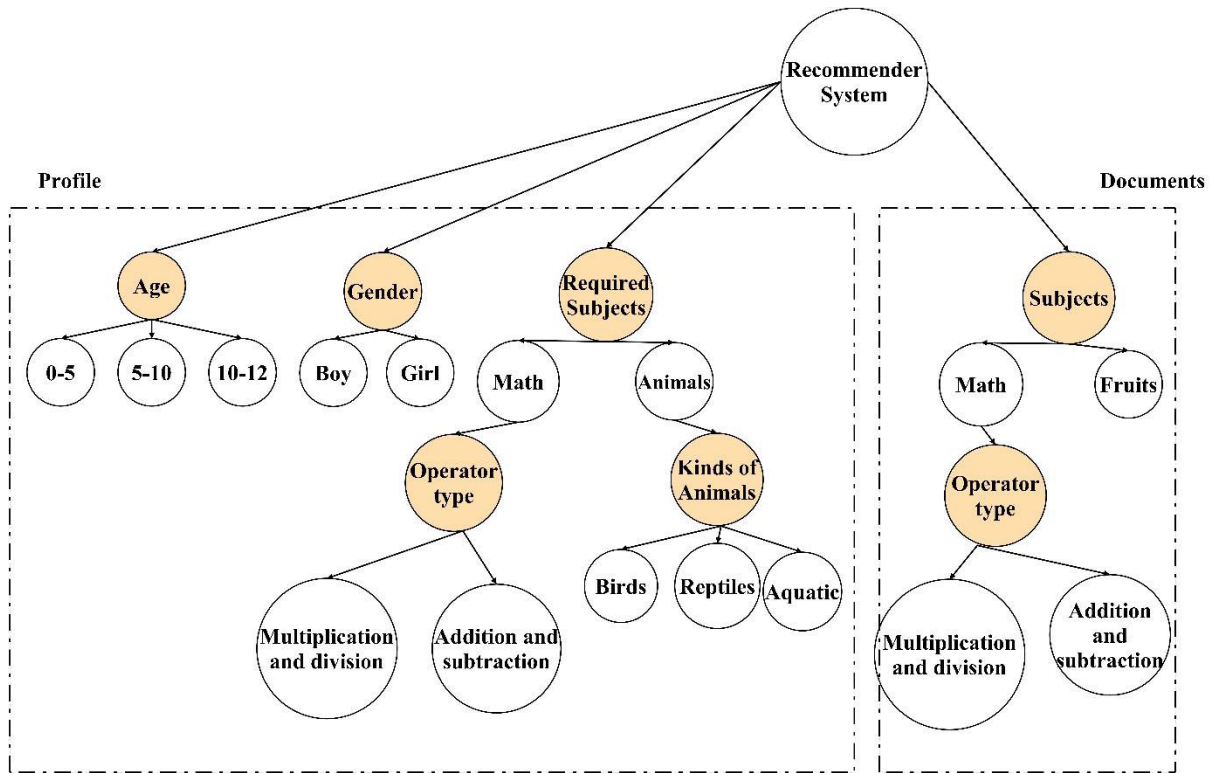


FIGURE 11. Educational documents and user profiles in the proposed recommender system.

following, how to check the similarity after selecting any type of matching function is explained.

In order to calculate the similarity of the documents with the subjects needed by the child, the Sim function is used. This function declares a number between zero and one as output. Zero means no similarity and one means the most similarity. Sim function is calculated as formula 4.

$$Sim(S_u, S_d) = \frac{1}{1 + \delta} \tag{4}$$

In formula 7, S_u is the subject of the user’s requirement, S_d is the subject of the document, and δ is the number of dimensions that the subject of the user’s requirement does not match with the subject of the document. For example, suppose for the child, mathematics is specified from the required subject dimension and addition and subtraction from the operator type dimension, and the subject of the document is only mathematics. In that case, there is a dimension that does not match the subject of the document with the subject required by the child ($\delta = 1$), and Sim is equal to 0.5 according to formula 7. After the Sim is calculated, documents are notified to each child in the order of their similarity to what they need. It is also possible to convert the dimensions specified in the user profile and documents into a numerical vector to check the degree of similarity. Table 1 shows an example of document dimension values and user requirements. Also, Table 2 shows the corresponding binary vector.

After calculating the binary vector, cosine similarity can be used for similarity. Formula 5 is used to calculate the cosine similarity of two vectors. Dot product and vector size are used in this formula. An angle of 0 degrees indicates the most significant similarity between the document and the child’s needs, and an angle of 180 degrees indicates the most minor similarity.

$$\cos(\theta) = \frac{d_1 \cdot d_2}{|d_1| |d_2|} \tag{5}$$

For the example stated in Tables 1 and 2, the similarity is equal to:

$$d_1 = (1, 1, 1, 0), d_2 = (1, 0, 0, 1) \\ \cos(\theta) = \frac{d_1 \cdot d_2}{|d_1| |d_2|} = \frac{1}{\sqrt{6}} \Rightarrow \theta = 66^\circ. \tag{6}$$

2) TYPES OF MATCHING FUNCTIONS

a: THE MUST MATCHING FUNCTION

This matching function looks for educational documents that contain the specified keywords in that document. Two cases can be considered for the must-matching function. In the first case, a document is notified to the user if all the specified keywords are present in the document. For example, if for a child, 5 keywords are defined as his educational needs, a document will be notified to him if all 5 keywords are present in it (regardless of the location of the keywords in the document). In the second case, if each of the determined

TABLE 1. An example of document dimension values and user requirements.

Type	Dimension values
Profile (d_1)	Animals, birds, herbivores
Document (d_2)	Animals, aquatics

TABLE 2. Binary vector example of table 1.

	Animals	Birds	Herbivores	Aquatics
Weight d_1	1	1	1	0
Weight d_2	1	0	0	1

keywords was in a document, that document will be notified to the user as a document of interest. For example, if the user had specified 5 keywords, if at least one of the keywords is found in a document (regardless of the location of the keywords in the document), that document will be notified to the user. In both cases, this matching function does not distinguish between the presence of specified keywords in the title, abstract, keywords, headings, in-text, etc.

b: THE WEIGHTED MATCHING FUNCTION BASED ON THE NUMBER OF KEYWORD REPETITIONS

Whether a keyword appears once or ten times in the text creates different values for the document. Also, the number of repetitions of different keywords creates different importance. Therefore, users can specify the minimum number of repetitions they want for each keyword in their profile settings, and a document will be notified if the set minimums are met.

c: THE WEIGHTED MATCHING FUNCTION BASED ON KEYWORD IMPORTANCE

The presence of a keyword in the document may be much more important to the user than the presence of other keywords. In this case, the user can determine their importance by giving a weight (between zero and one) to the keywords. In this function, it is necessary to define a threshold limit, and if the sum of the weights in the document exceeds the threshold limit, that document will be notified to the user.

d: THE BOOLEAN MATCHING FUNCTION

In the Boolean function, the user can express different scenarios of keywords with “AND”, “OR” and “NOT” operators. For example, if the user is interested in receiving documents that contain one of the two keywords “learning style” and “educational game” and not both, he can submit his request using the following Boolean function:

$$((\text{NOT} (“learning style”)) \text{ AND } (“educational game”)) \text{ OR } (“learning style”) \text{ AND } (\text{NOT} (“educational game”)))$$

The advantage of this function is to create different scenarios based on the interests and needs of the user.

3) INTELLIGENT RECOMMENDATION OF EDUCATIONAL MATERIALS

In recommending educational materials to each child, we can use three methods of targeting recommendation, tailoring

recommendation and recommendation considering the amount of dissemination of educational materials, each of which is explained in the following.

a: TARGETING RECOMMENDATION OF EDUCATIONAL MATERIALS

In this method, centrality measures can be used to identify children with bigger influence and power. In such a way, we allocate the educational material that we intend to learn to children with higher centrality.

b: TAILORING RECOMMENDATION OF EDUCATIONAL MATERIALS

In this method, according to the educational status of children, special and customized educational materials are done. For example, a child may be stronger in math and another child may be stronger in English. Therefore, educational materials are allocated according to the ability of each child.

c: RECOMMENDING EDUCATIONAL MATERIALS CONSIDERING THE AMOUNT OF DISSEMINATION

In this method, the dissemination of educational materials is taken into consideration and the allocation of educational materials is done in such a way that it has the most dissemination in the children’s educational network. In this method, threshold and cascade models can be used.

C. THE OUTPUT OF THE RECOMMENDER SYSTEMS

After the matching functions determined by the user have found documents that match his needs, a notification should be sent to the user’s mobile phone. In document notification, things such as the notification method, notification content, and order of notification documents should be considered, the settings of each were explained in the profile section.

V. RESULTS

The simulation and implementation of the proposed recommender system have been discussed in this section. Also, the efficiency of this system has been evaluated, and the results have been discussed.

A. SIMULATION OF CHILD EDUCATIONAL RECOMMENDER SYSTEM

1) SIMULATION OF CHILD’S EDUCATIONAL RECOMMENDER SYSTEM USING NETLOGO

In this section, the simulation of the child’s educational recommender system using NetLogo has been discussed. The traditional method of education, and teaching with the proposed method, are simulated. One hundred children are considered as “turtles” randomly scattered in the environment. Also, educational materials are assigned to 20% of children randomly. The cascade model has been used to disseminate educational materials on the network. The probability that child w learns from teaching child v is $P_w(v) = 0.5$. In fact, whenever two children reach a place with a difference

of one “patch”, they teach each other and the probability of learning is 0.5. Therefore, children in red are not learning, and children in green are children who have successfully learned the educational material. In the traditional method of education, the intelligent recommendation of educational materials based on different centralities of children is not considered. Also, the proposed educational protocols, such as the protocol for requesting help in learning a subject and using smart bulletin boards and mobile technology, have not been considered. Figure 12 shows the simulation of the traditional method of education in NetLogo.

In the following case, the simulation of the proposed educational method has been done. In this case, 20% of children have also provided educational materials. But the recommendation of educational materials has been intelligent and based on the different centralities of children. Also, the protocol of asking for help in learning a subject and using smart bulletin boards and mobile technology has been used. 30% of the environment space has been used as smart bulletin boards equipped with NFC, randomly scattered in the environment and marked with blue colour. Using mobile technology, children placed in these “patches” can enhance their learning by reading the NFC tags off the smart bulletin board. Also, the probability of learning in these “patches” is 0.5. Figure 13 shows the simulation of the proposed educational method in NetLogo.

Also, Figure 14 shows the results of the simulation of the traditional method of education and the method of the educational recommender system in NetLogo.

As seen in Figure 14 (a), in the traditional method of education, 180-time steps are needed to teach all the children. While in the proposed educational method shown in Figure 14 (b), 75-time steps are needed to learn all the children. The proposed educational method will speed up the learning process by intelligently recommending educational materials based on different centralities of children.

2) SIMULATION OF CHILD EDUCATIONAL RECOMMENDER SYSTEM USING R

In teaching children to each other, one or more educational materials may be taught incorrectly, and this incorrect content will be disseminated in the children’s educational network. One advantage of the presented educational recommender system, such as the protocol for requesting help in learning a subject using mobile technology, is that children could use this system as an educational supplement. Using the educational recommender system, children are informed of incorrect content and prevent education and dissemination it to other children. In Figure 15, the simulation of the traditional method of education is discussed, which may disseminate incorrectly educational content in the network. In this simulation, 100 children who randomly interacted with each other were used. Also, scatter and pie charts have been drawn regarding the state of disseminating incorrect information. In this simulation, it is assumed that the dissemination of incorrect information started from child 30. Nodes are

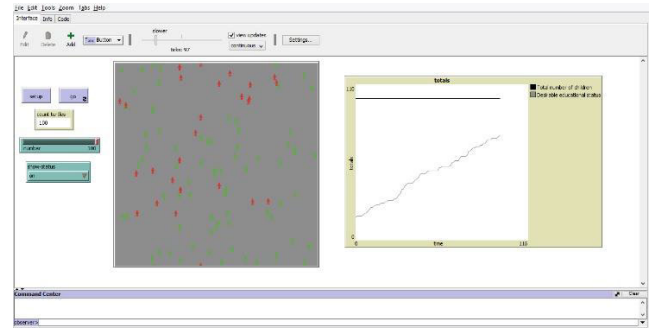


FIGURE 12. Simulation of the Traditional Method of education in NetLogo.

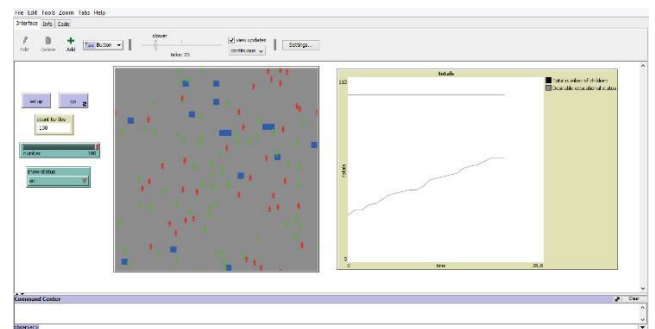


FIGURE 13. Simulation of the educational recommender system method in NetLogo.

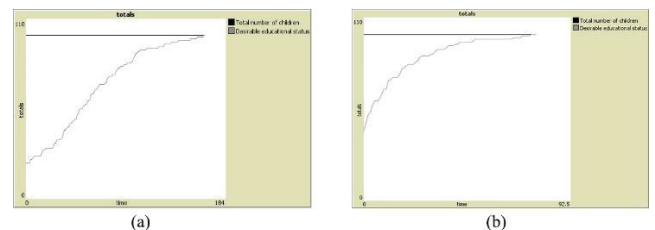


FIGURE 14. The results of the simulation of the traditional Method of education and the proposed educational Method in NetLogo (a) Traditional Method of education (b) Proposed educational method.

children. Green colors indicate correct content, and red colors indicate incorrect content.

As can be seen in Figure 15, if one child (child number 30) makes a mistake, the dissemination of incorrect content will happen a lot in the network. In the second part, which is shown in Figure 16, the simulation using the educational recommender system is discussed. The number of children was 100 randomly communicating with each other. It is assumed that 70% of the children use the educational recommender system, which is randomly selected in the network. Children who use the educational recommender system in the network, if they receive incorrect information, prevent it from spreading and spread the correct content. The nodes are children. Green colors indicate receiving correct educational content. Red colors indicate receiving incorrect educational materials. Blue colors represent children who use the educational recommender system and have received incorrect information, blocked the spread of incorrect content, and spread the correct content.

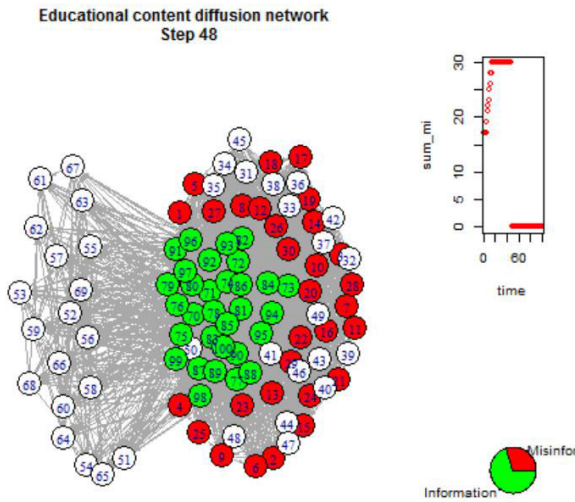


FIGURE 15. Simulation of the dissemination of incorrect information in the traditional method of education.

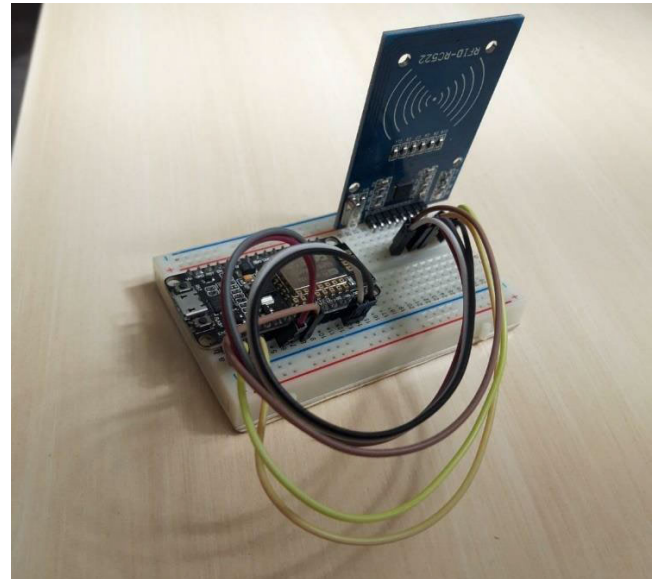


FIGURE 17. The hardware part of the children’s educational recommender system.

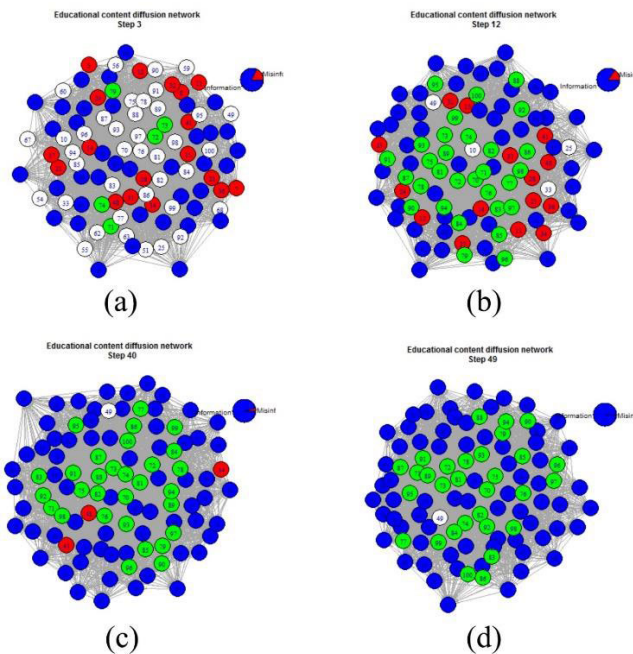


FIGURE 16. Simulation of the dissemination of incorrect educational information in the method using the educational recommender system.

As seen in Figure 16, children’s use of the educational recommender system will cause the loss of incorrect educational information.

B. IMPLEMENTATION OF CHILD EDUCATIONAL RECOMMENDER SYSTEM

In this section, the educational recommender system has been implemented. First, the technical part of implementing the educational recommender system has been discussed. Then, the results of implementing the educational recommender system in identifying and improving the educational status of children have been examined.

In the hardware part, a nodemcu microcontroller (esp8622) was used. One of the advantages of this board is that it has a WiFi module inside. This board includes two different versions: the cp2102 version, which is complete but more expensive, and the ch340g version, cheaper but requires driver installation. The version used in the design of the educational recommender system is cp2102. After preparing this board, the library was installed in the Arduino software for programming purposes. Also, the libraries used in the system design included WiFi, MQTT and RFID Reader. After installing the MQTT library, the broker was installed. The RFID Reader library is for reading and writing information using RFID technology that uses the MFRC522 module. Another issue that needs to be clarified is how the devices communicate with the MQTT server. This connection must be in the MQTT platform and follow its standards. Because devices communicate with channels in the MQTT method, it must also be planned for channels. For this purpose, the topics were set based on the devices available in the network. The server uses the topics to send the required message to the device. If a device wants to send data to the server, it sends the data to the root topic where the server is a member. The number specific to each device can be assigned to the device in two ways:

- In the first method, the number specific to that device can be entered manually and at the time of uploading the code to the device.
- In the second method, so that when adding a new device to the network, there is no need to change the codes on the server side or the devices, we create an event in the topic so that each new device in the network can receive its number from the server.

In the design of the educational recommender system, in order for the new device to be able to connect to the

```

124 Serial.print(F("In dec: "));
125 printDec(rfid.uid.uidByte, rfid.uid.size);
126 Serial.println();
127 return CardArray;
128
129
130 }
131
132 byte tempi;
133 switch(CardState){
134 case 'R':
135     tempi='R';
136     Serial.println('R');
137     return &tempi;
138     break;
139
140 case 'B':
141     tempi='B';
142     Serial.println('B');
143     return &tempi;
144     break;
145
146 default:
147     //
148     //
149     //
150     //
151     //
152     //
153     //
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155     //
156     //
157     //
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FIGURE 18. The software part of the children’s educational recommender system.

network, by default, it sends a message to the “Root/New Node” topic with the first connection to the network, and this device also joins the “New” topic. Upon receiving a new message in this topic, the server searches the database and sends the number of the last device plus one to this device in the “New” topic. Also, some functions were defined. The first function, related to the WiFi library, has the task of executing the code to connect to WiFi. The second function, which belongs to the use section of MQTT, has the task of executing when a message comes from the MQTT server side. In the third function, the task of connecting to the MQTT server is followed. The fourth function is a function that is executed when the device starts working, and its task is to perform initial settings. Figure 17 shows the created microcontroller.

Also, in Figure 18, the output related to Card Hex identification in the design of the educational recommender system is shown.

Also, coding in Python was done in order to analyze the adjacency matrix of children’s educational network and to identify the status of each child. For this purpose, the numpy library was used. In addition, the networkx library was used to draw children’s educational network graphs, so that teachers can understand and analyze better. Also, e-mail.mime.multipart was used in order to use e-mail to notify each child’s parent’s mobile smartphone about their child’s educational status and to attach reinforcement educational materials matched to each child’s educational status using the introduced matching functions.

After designing the educational recommender system, this system was implemented and evaluated on children. For this purpose, the designed system was tested on 36 children aged

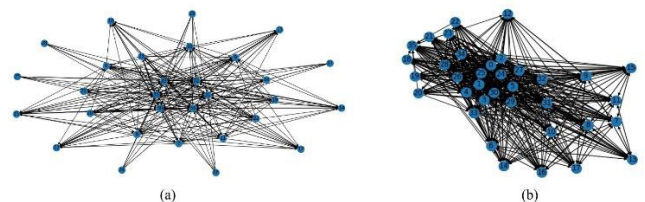


FIGURE 19. Educational network of tested children (a) Before using the educational recommender system (b) After using the educational recommender system.

8 to 10 years. Children’s educational network was extracted. Then, this network was analyzed using centrality measures and based on the described protocols and explained coding. The children’s learning network was drawn using Python to visualize the data and enable teachers to better analyze it. The educational status of each child was determined. Using the educational recommender system, decision-making and real-time monitoring were done based on the educational status of each child. Educational materials were personalized for each child according to their educational status. Also, in recommending educational materials to children with a higher centrality, attention was paid in order to spreading more educational materials among children. Educational materials matched to each child’s needs and educational status were sent to the e-mail of the child’s parents and social networks on their smart mobile phones to inform parents more quickly about the educational status of the child and the stated solutions. Figure 19 shows the children’s educational network output, before and after using the educational recommender system, drawn using Python.

In Figure 19, the number of 36 children is represented by nodes. The links represent education between children.

```

Email_ERS.py - C:\Users\Mohammad Moradi\AppData\Local\Programs\Python\Pyt...
File Edit Format Run Options Window Help
from email.mime.multipart import MIMEMultipart
from email.mime.text import MIMEText
import smtplib

# create message object instance
msg = MIMEMultipart()

message = "Your child's learning status is weak. Please use the attached educati

# setup the parameters of the message
password = "
msg['From'] = "Educational.RecommenderSystem@outlook.com"
msg['To'] = "Mohammad.ali.razavian@outlook.com"
msg['Subject'] = "Your child's learning status"

# add in the message body
msg.attach(MIMEText(message, 'http://h41-239.catalyst.net.nz/sites/default/files/

#create server
server = smtplib.SMTP('imap-mail.outlook.com: 587')

server.starttls()

# Login Credentials for sending the mail
server.login(msg['From'], password)

# send the message via the server.
server.sendmail(msg['From'], msg['To'], msg.as_string())

server.quit()

print ("successfully sent email to {}".format(msg['To']))
    
```

(a)

```

Python 3.7.2 Shell
File Edit Shell Debug Options Window Help
Python 3.7.2 (tags/v3.7.2:9a3f0492, Dec 23 2018, 23:09:28) [MSC v.1916 64 bit
(AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
RESTART: C:\Users\Mohammad Moradi\AppData\Local\Programs\Python\Python37\Email_
ERS.py
successfully sent email to Mohammad.ali.razavian@outlook.com
>>>
    
```

(b)

FIGURE 20. Part of the educational recommender system related to the Python code to send an e-mail to the child’s parent’s mobile phone regarding the child’s educational status.

Children are labelled with numbers 0 to 35. In Figure 19 (a), since children 0 to 5 have not had any successful training and learning and are isolated nodes, they are not drawn into the network. As it is clear from the educational networks in Figure 19, the links of the educational network have increased after using the educational recommender system.

Also, Figure 20 shows a part of the educational recommender system related to the Python code of sending an e-mail to the child’s parent’s mobile smartphone. Figure 21 shows the email sent to the mobile smartphone of the parent of a child who was weak in learning and attaching the educational file to the child’s needs.

In Table 3, the comparison of the local and general evaluation parameters of the children’s educational network, before and after using the educational recommender system, has been discussed.

As seen in Table 3, the educational recommender system has improved children’s learning by more than twice. Also, Bayesian modelling was done in order to check the efficiency of the educational recommender system. Figure 22 shows the conditional probability model of children’s educational status. Experiment 1 is before the implementation of the educational recommender system and experiment 2 is after the implementation of the educational recommender system. Using the conditional probability model of Figure 22, the

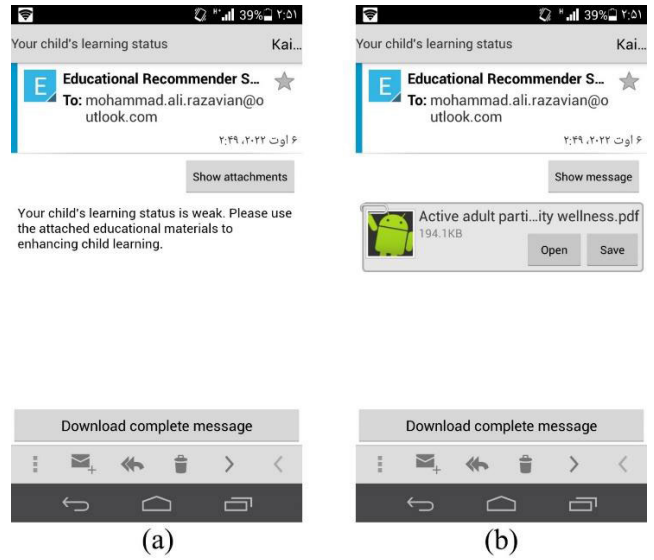


FIGURE 21. An example of an e-mail sent to the mobile phone of the parent of a child who was weak in learning and attaching an educational file matched to the child’s needs.

TABLE 3. Comparison of local and general evaluation parameters of the children’s educational network, before and after using the educational recommender system.

Method	Maximum in-degree	Maximum out-degree	Sum of in-degree (out-degree)	Average degree
Traditional method of education	18	18	288	8
Educational recommender system	24	30	612	17

probability of the child’s new status can be calculated based on his previous status.

For example, in Figure 22, the probability that child *i* has low input communications (other children’s communication with child *i*) before implementing the educational recommender system is equal to 0.16 (Node A). Also, the probability that he has low output communication (child *i*’s communication with other children) is 0.33 (Node B). In the second level, which is related to before recommending educational documents to the nodes of the first level. For example, in node C, the probability that child *i* is a weak learner, provided that he has low input communication and low output communication, is equal to 1. The third level is the educational status of children after implementing the educational recommender system and recommending educational documents to children. At this level, the probability that child *i* is a weak learner after the implementation of the educational recommender system, provided that before the implementation of the educational recommender system, he is also a weak learner and a weak educator is equal to 0.17. The low probability shows that after the implementation of the educational

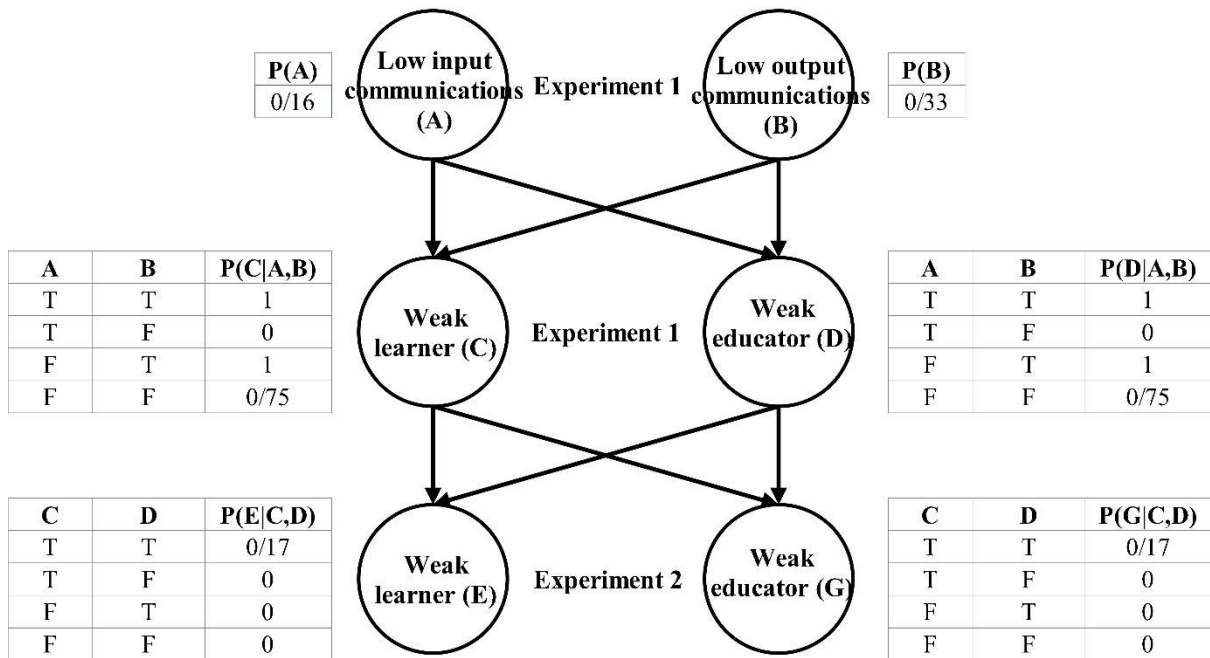


FIGURE 22. Calculated probabilities in the implementation of the conditional probability model of children’s status.

recommender system, the status of the majority has become a good learner. This shows the desired performance of the proposed educational recommender system.

VI. CONCLUSION

The results of implementing the proposed educational recommender system revealed that it improved children’s educational status. In addition, the following benefits of the proposed educational recommender system can be mentioned:

- All steps in the proposed educational method, from identifying each child’s educational status to providing the educational materials required by each child, are completed automatically and in the shortest amount of time possible, increasing accuracy, ease, and efficiency.
- The proposed educational network is safe from invading vulgar content to children (because children are connected through the NFC and wearable mobile devices and are not directly connected to the Internet).
- The proposed educational method restores social relationships in children.
- In the educational recommender system, educational protocols were stated that can prevent the spread of incorrect content.
- The educational recommender system personalizes education for each child according to the educational status of that child.
- In this system, it is possible to select how educational documents are accessed (using mobile phones, e-mail, social networks, etc.), determine the notification method, determine the matching function, determine

the content of educational documents, etc., in order to increase ease and efficiency.

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