Context Aware Classroom for Interactive Teacher and Student Collaboration to Enhance the Learning Outcome of the Classroom

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Abstract

Technology has advanced rapidly in recent years. Development is also occurring in the educational sector. The technology that has been introduced in recent years is based on the development of the classroom environment, such as the use of smartboards, data storage on a server, and E-learning. However, there are issues with understanding and creating an interactive environment between the teacher and student. Often, social and cultural obstacles exacerbate difficulties in the classroom rather than providing a positive learning environment. This paper discusses the issues confronting our educational system. The issues facing our educational system are examined in this study. In order to improve the future of our country, the paper then explores potential elements that could be incorporated into our educational system to foster a more interactive and better understanding among the younger generation. It also offers a cost-effective way to improve students' learning capabilities by strengthening their relationship with their teachers, which in turn improves their attitude, behavior, and perception of the subject. The results of the algorithms' implementation in a classroom setting are presented in this study.

Keywords—Field of education, classroom setting, context-aware computing, teamwork, teacher-student interaction, educational technologies

1 Introduction

Margaret Mead once stated, "Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has" [1].

The education system, as it is today, mainly measures students through their academic performance and is most concerned with pass or fail results without considering personal growth or guidance. Additionally, there is a lack of communication between the teachers and students, and this has been noted especially when the two groups are from different cultural or regional backgrounds. However, a situation is quite different when a teacher and student are from the same region, then they are more likely to share a mutual understanding of each other's perspectives, challenges, and needs. In such cases, the teacher is enabled to give the student more relevant and effective support.

Yet, modern smart classrooms basically mean high expenditures because of the application of advanced gadgets and infrastructure, which consequently leads to financial problems for the schools. In response to such a situation, our research offers a classroom that is aware of the context and thus allows teachers and students to carry on intellectual discussions with the least possible economic burden. The pair mentioned here is formed on the basis of common local and situational knowledge; thus, the intention is to increase student involvement and academic performance.

1.1 Key Contributions of the Study

- Recognition of a Problem in conventional education systems that are overly dependent on academic results and, however, ignore both the student-teacher relationship and the understanding of the local context.
- An Innovative Model of Context-Aware Classroom that facilitates students and teachers' intellectual pairing based on local and cultural correspondences has been suggested.

ISSN: 2523-0379 (Online), ISSN: 1605-8607 (Print)
DOI: https://doi.org/10.52584/QRJ.2301.05

- The Presentation of a Cheap Smart Classroom System that lessens the financial burden on organizations but still provides the advantages of smart learning.
- Due to the improvement of the teacher-student relationship and the offer of personalized educational help through the understanding of the context, the paper is a direct contribution to Effective Learning.

This method illustrates a completely new contribution to the educational system as it focuses on the promotion of effective learning through the intellectual matching in an economical and smart classroom environment.

The quote underscores the transformative power of education, which goes beyond mere transmission of knowledge. Education is fundamentally the process of shaping a student's behavior in a way that leads to positive and meaningful outcomes [2][3][4].

If learning does not result in behavioral change, then its true purpose is lost. Hence, educators must not only possess subject-matter expertise but also continuously refine their teaching methodologies [5]. The concept of teaching itself revolves around the act of delivering instruction with a purpose. This process should be aligned with clear objectives and measurable outcomes, aimed at fostering beneficial behavioral modifications in students [6]. Learning, as an ongoing and dynamic process, is influenced by the environment in which it occurs. Educational environments can generally be categorized into three approaches:

- **Teacher-Centered:** In this approach, the teacher emphasizes their own delivery rather than student comprehension, which often results in slower learning [7].
- **Learner-Centered:** This approach allows students to learn independently at their own pace, with minimal teacher interaction. Although learning may still occur, the teaching process itself remains limited [8].
- **Optimal Learning:** This model encourages simultaneous engagement in teaching and learning. It proves more efficient than student-centered learning in achieving desired educational outcomes within a reasonable time frame [9][10].

The overarching goal of instruction should be the holistic development of a student's personality, encompassing both competence and character [11]. This can be significantly enhanced through the integration of educational technology, which involves the systematic design and implementation of instructional tools and methods to improve learning outcomes [12].

TABLE 1: Character Growth

CHARACTER GROWTH	
CHARACTER STRUCTURE	**EVOLVING CAPABILITY**
Dutifulness	Capabilities
Morals	Services
Communal Principles	IQ and EQ
Ethical Principles	Expertise
Behaviors and Regard	Knowledge about the theme

To support this goal, this study proposes the design of an intelligent decision support system tailored for educational contexts. This system aims to collect, refine, and validate data to assist both teachers and students in improving performance and fostering meaningful learning experiences [13].

Ultimately, the envisioned system seeks to remove barriers related to unfamiliar classroom settings by promoting intercultural openness and strengthening student-teacher relationships. This effort is especially significant as it aims to enhance students' ethnic awareness and build stronger emotional bonds in a knowledge-based learning environment [14].

2 Background/Literature Review

Building on the foundation of effective teaching strategies, Downey emphasizes that to positively impact students' lives, teachers must implement instructional methodologies that create an engaging classroom environment. When such environments are established, the risk of academic failure among students significantly decreases [15].

The role of educational technology is critical in achieving this. The Association for Educational Communications and Technology (AECT) defines it as the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources [16]. Through well-designed tools and strategies, teachers can better engage students and enhance academic outcomes.

In addition to academic engagement, emotional and social interactions in the classroom play a vital role. For example, Abry et al. highlight the significance of simple morning greetings in fostering emotional connections and social engagement between teachers and students [17]. These interactions provide daily opportunities for constructive communication, essential for a supportive learning environment.

Beyond cognitive development, teachers are also responsible for character building. A student's knowledge, if not paired with ethical development, can be detrimental to society [18]. Therefore, teaching must include character formation as a core objective. Table 1 outlines key dimensions of character growth and evolving capabilities that result from personality development. The responsibilities teachers bear underline their pivotal role in shaping students' values, beliefs, and attitudes [14]. Through their communication and interpersonal relationships, teachers can deeply influence student perspectives and foster lifelong learning habits. However, Rothstein et al. argue that education policy often reduces complex learning outcomes to simplistic test scores, a practice that fails to reflect the holistic development schools are expected to deliver [15].

Teacher-student bonding is particularly significant in early education. In the absence of strong parental attachment, the teacher often becomes a central figure in the student's life, providing emotional and social grounding [14]. Even when strong parental relationships exist, secondary attachment to a teacher can still lead to positive outcomes. At the same time, the rapid advancement of technology has left many educators hesitant about adopting e-learning methods. Concerns about its productivity and impact have led to skepticism among teachers [19]. However, when effectively utilized, technology greatly enhances both teaching strategies and student performance [20]. In recent years, Social Emotional Learning (SEL) has emerged as a powerful approach to prepare students with essential life and employment skills. Table 2 outlines key SEL competencies that contribute to a well-rounded and emotionally intelligent learner.

SEL also aligns with the principles of Positive Youth Development (PYD). In classrooms, educators support students in identifying goals, making informed decisions, and reflecting on their actions through collaborative and reflective activities such as peer review and journaling [17].

To facilitate this personalized approach, the concept of context-aware computation has been introduced. This allows for dynamic adaptation of educational content based on student-specific data. As shown in Figure 1, our system classifies individuals based on four contextual elements:

Profile: Includes personal details such as skills and spoken languages.

Location: Considers geographic background or travel history, which influences learning behavior.

Time: Refers to how recent or relevant the data is, including time spent in specific environments.

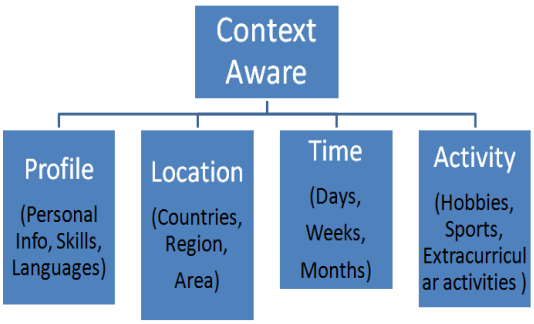


Fig. 1: Context-aware Classification

Activity: Reflects interests, hobbies, sports, and preferred social interactions.

By incorporating these contextual features, the proposed system supports personalized learning and improved educational outcomes [21][22][23]. To operationalize this, recommendation algorithms are needed to filter and present relevant information tailored to individual learners. These algorithms help suggest learning resources or strategies aligned with each student's context and preferences [24][25][26].

The following three systems serve as the foundation for our research:

1) Collaborative Filtering
2) Content-based filtering
3) Hybrid Recommendation Systems

2.1 Collaborative Filtering

Collaborative filtering recommends items to a user based on the preferences and behavior of similar users. It relies on user-item interactions and does not require detailed item information [26][27].

2.2 Content-Based Filtering

Content-based filtering recommends items by analyzing the characteristics of items a user has previously liked. It uses item features and user profiles to find matches [27].

2.3 Hybrid Recommendation Systems

Hybrid systems combine collaborative and content-based methods to leverage the strengths of both approaches. They improve accuracy and reduce limitations like cold-start and sparsity issues [27][28].

TABLE 2: Social Emotional Learning

	Workshop Skills	Explanation
1.	Understanding	Students can appreciate and understand one another
2.	Instinct Switch	Students can settle down and get started on the work they have been given.
3.	Emotion Recognition	In the classroom, students can adjust the atmosphere by observing the attitudes of their teachers and classmates.
4.	Emotion Management	Students are emotionally resilient and do not allow feelings from a family conflict to show on their faces.
5.	Communication	They can communicate well. They are able to listen to others, concentrate on their problems, and maximize each relationship by maintaining its strength.
6.	Assertiveness	The kids are brave in their decision-making and possess the self-assurance to express their desires to others. However, they also make everyone happy and are considerate.

3 Problem Statement

How educators are doing with combining educational technology and character development and social-emotional learning (SEL) is becoming complicated in many countries due to the multi-ethnic learning they handle with kids. Standardized assessment data are not a true reflection of the educational success rate, and this is seen in places where tests are often used. However, the problem is compounded by the fact that not everyone can see the core of the problems facing students. There are many issues that teachers have to deal with, including the fact that parents are not always there for their children, and some may decide not to use technology as a form of communication. What is needed is a search for the role educators can play not only in teaching children the use of technology but also in character development, as well as in the social and emotional aspects, especially in environments where the bond between kids and parents is disappearing, and technology yet a new thing to some.

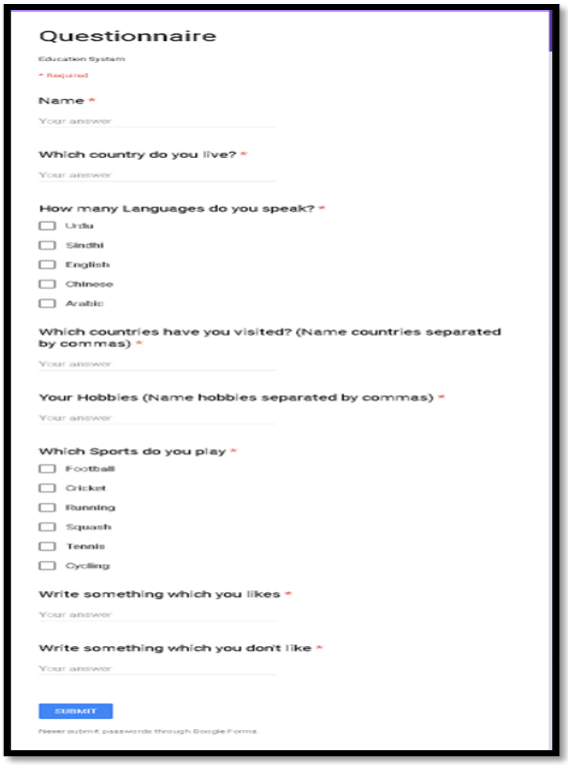


Fig. 2: Questionnaire Form

4 4. Research Methodology

This paper employs the Design Science Research Methodology (DSRM), which includes requirement gathering, system design, implementation, testing, and presentation of results. Requirements were collected through a Google Form. The design phase includes the system architecture, flowcharts, and use case diagrams. The implementation section presents screenshots of the developed prototype. The testing and results are demonstrated using tables, pie charts, and bar charts.

4.1 Requirement Gathering

A Google Form was used for requirement gathering, shown in Figure 2. Data was collected from 100 students and 10 teachers shown in Table 3, and their responses were cross-matched for consistency and analysis.

TABLE 3: Demographic Data of Teachers and Students

Group	Total	Gender	Level of Education
Teachers	10	70% Male 30% Female	Graduates
Students	100	80% Male 20% Female	Undergraduates

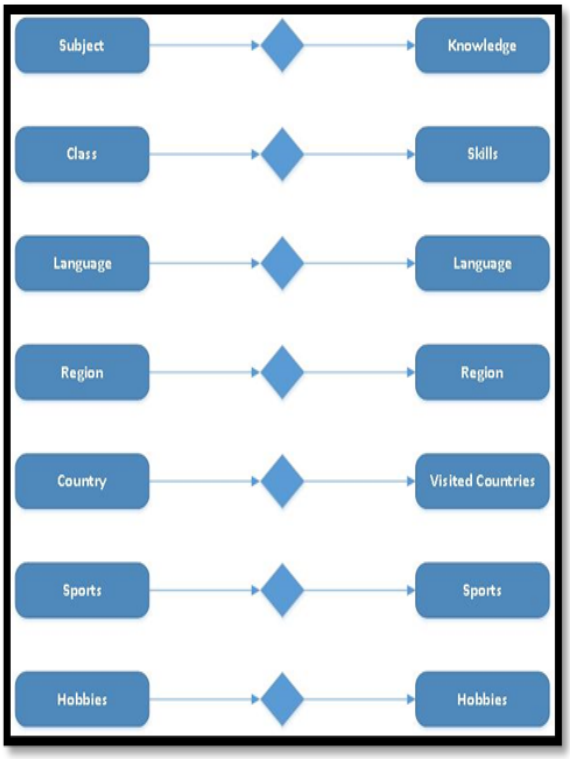


Fig. 3: Rule Engine of student context and teacher context

4.2 System Design

The engine takes input from students and teachers to recognize those who have common or close features for use in the Rule Engine. This Rule Engine uses the collaborative filtering algorithm. Such a system enables students and teachers to be matched in a way that it is possible to identify the most suitable tutor/teacher for a student. All taken information about a student is up to his personal details, class, subjects, languages, region, and hobbies. Similarly, the information related to the teacher includes personal details, subject fields, skills, languages, region, history of travel, and hobbies. Illustrated in Figure 3.

4.3 Architecture

The system has a straightforward architecture. Teachers' and students' data are collected. An Excel sheet

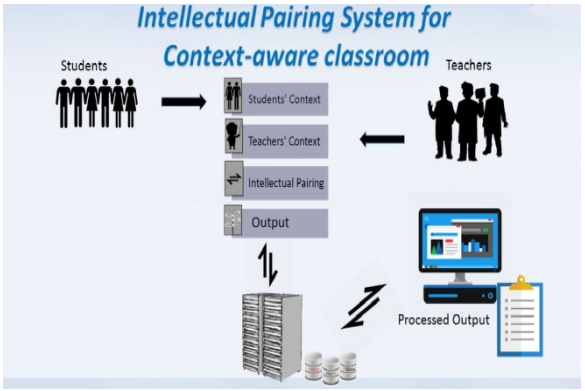


Fig. 4: Architecture of the Intellectual Pairing System

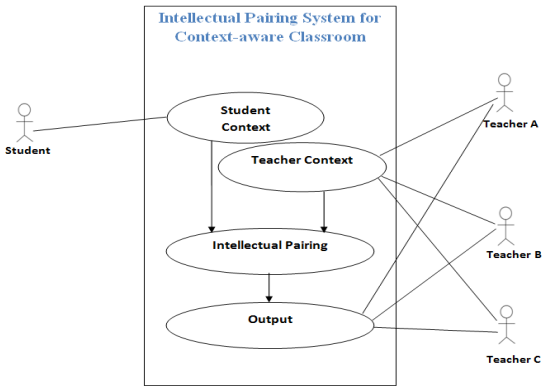


Fig. 5: Use Case Diagram of Intellectual Pairing System

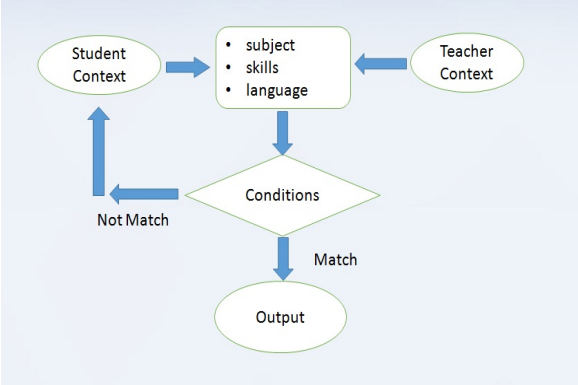
is then used to store the gathered data. After that, the file is entered into the program. The software then employs a collaborative filtering technique to use intellectual pairing. As seen in Figure 4, the procedure is repeated until every student and teacher is compared.

The use case diagram, as seen in Figure 5, is the most straightforward method of illustrating how users interact with the system. According to our use case diagram, the intellectual partnering system will obtain student data first, followed by teacher data.

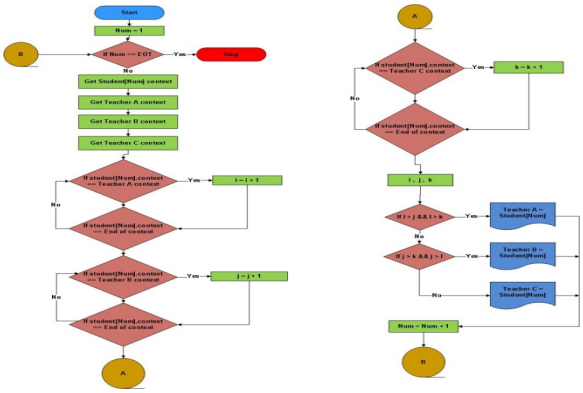
The flow chart in Figure 6a and Figure 6b illustrates how our system will make the choice. When the information has been collected and entered into the system. The judgment will be based on the degree of similarity between the teacher and the student once all entities have been compared.

4.4 Implementation

The system and its outcomes were tested in a console-based environment. Figure 7 illustrates how the GUI was made. Suitable usernames and passwords are allotted to each school and have a default administrative login for maintenance purposes.



(a)



(b)

Fig. 6: Flowchart Diagrams of Intellectual Pairing System

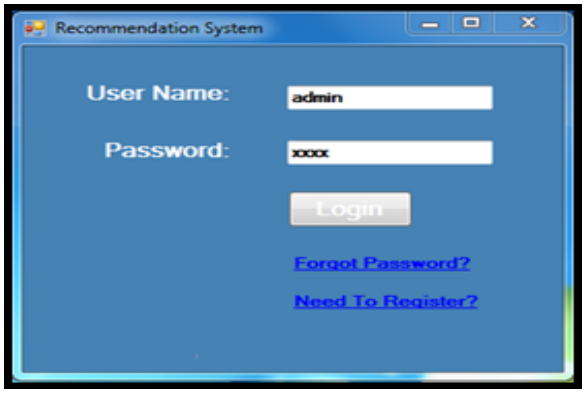


Fig. 7: Recommendation System Login Panel

The school is allowed to get the student data and the teachers' data, teaching a particular subject, to find the best possible pairing between them. The files can be browsed, and then the process button is pressed.

As seen in Figure 8, the computer will begin computing based on collaborative filtering after the Process button has been selected. It will then sort the pupils according to characteristics that teachers share.

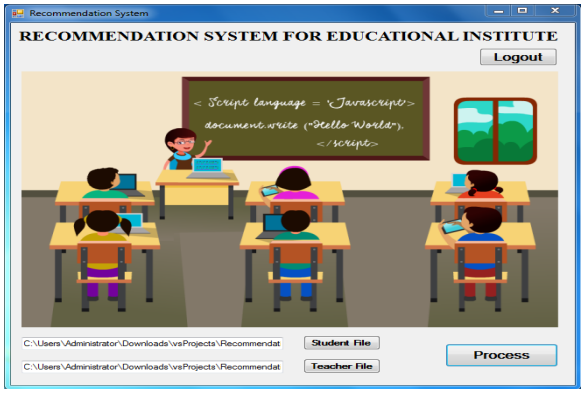


Fig. 8: Software for Recommendation System for Educational Institute

To print the report generated, the "PRINT REPORT" button is used. After that, the data can be printed onto paper, and Figure 9 illustrates how the outcome will appear on the screen. The report can be further analyzed by the school's admission department, and suitable changes can be made to balance the class, as we will have a quantitative value for each teacher-student pairing.

4.5 Results

To evaluate the results, a user feedback form was utilized, shown in Figure 10. Feedback data was gathered from various centers, as shown in Figure 11, and the implementation and use of the software prototype.

The software was sent to centers that agreed to collaborate with us in our research. The pie chart in Figure 12 shows the ratio of Male 65% and Female 35% administration that accepted our proposal and implemented it in their centers.

The software assisted the centers in improving their classes, as seen in Figure 13. Six centers expressed significant support for our system. Eight people believed that the system had benefited them. Only one center disagreed with the class improvement results, while four offered neutral opinions.

Information about the satisfaction of the centers' administration with our software is shown in Figure 14. Seven centers expressed great satisfaction with our system. Nine people believed that the method had produced positive outcomes. Only one center expressed disagreement with our system, whilst two offered neutral comments.

Information on our software's referral to other centers and institutes is shown in Figure 15. Nine centers were eager to assist other institutions. Nine expressed the opinion that they would recommend this system to other institutions. Only one center opposed

Fig. 9: Software Print Report of our System

recommending our system, while two offered neutral comments.

5 Research Hypotheses

In order to gauge the effectiveness and influence of a context-aware classroom environment that is designed to be sensitive to the surroundings, the following hypotheses are put forward:

- **H1:** An intellectual partnership between teachers and students who have the same regional or contextual background is the major factor that leads to significantly improved students' learning outcomes significantly improved.
- **H2:** A classroom that is aware of the context will be able to improve the student–teacher relationship better than traditional classroom settings.
- **H3:** The smart classroom setup as proposed in this paper can still provide effective learning support with a much lower economic cost than conventional smart classroom setups, no matter the level of confidence.
- **H4:** The students who are in context-aware classrooms will have more participation and satisfaction than those who are in the standard classrooms.
- **H5:** The teachers who get students who are in the same contextual setting as them will be able to recognize the individual learning problems of the students and help solve them.

TABLE 4: Hypothesis Testing Results

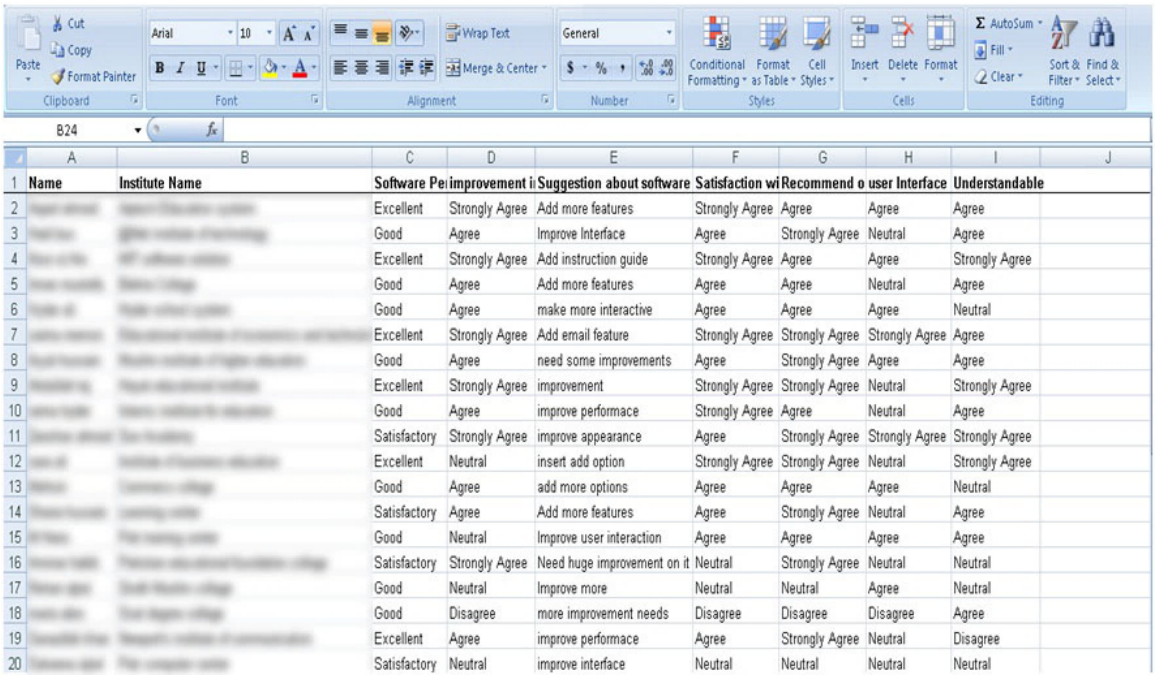
Hypothesis	Cronbach's Alpha Acceptance	result
h1	0.765	recognized
h2	0.775	recognized
h3	0.877	recognized
h4	0.899	recognized
h5	0.854	recognized

6 Conclusion

We first considered ways to enhance Pakistan's educational system without utilizing expensive machinery by coming up with a simple, low-cost solution that could be readily implemented in every school and

Fig. 10: Feedback Form

college. We conducted a literature analysis in order to examine this problem and discovered that many emerging nations also experience this problem. According to studies from African literature, fostering a deeper relationship between teachers and students can help address this problem. The classroom's imposing border should be eliminated, and a learning environment should be established. If the likelihood of a pupil and a teacher being roughly equal and having similar psychology, that is, the same social and cognitive traits, then this may have happened. We created an algorithm that evaluates the students' social and regional characteristics with their future professors in order to solve this issue. The student is placed in the class where he is most likely to get along with the teacher. These results can be further improved when the system is in a certain school and gathers students' feedback after completion of each academic year, changing the weightages of sortable values, and then running the recommendation system.



	A	B	C	D	E	F	G	H	I	J
1	Name	Institute Name	Software Pe	improvement i	Suggestion about software	Satisfaction wi	Recommend o	user Interface	Understandable	
2			Excellent	Strongly Agree	Add more features	Strongly Agree	Agree	Agree	Agree	
3			Good	Agree	Improve Interface	Agree	Strongly Agree	Neutral	Agree	
4			Excellent	Strongly Agree	Add instruction guide	Strongly Agree	Agree	Agree	Strongly Agree	
5			Good	Agree	Add more features	Agree	Agree	Neutral	Agree	
6			Good	Agree	make more interactive	Agree	Agree	Agree	Neutral	
7			Excellent	Strongly Agree	Add email feature	Strongly Agree	Strongly Agree	Strongly Agree	Agree	
8			Good	Agree	need some improvements	Agree	Strongly Agree	Agree	Agree	
9			Excellent	Strongly Agree	improvement	Strongly Agree	Strongly Agree	Neutral	Strongly Agree	
10			Good	Agree	improve performace	Strongly Agree	Agree	Neutral	Agree	
11			Satisfactory	Strongly Agree	improve appearance	Agree	Strongly Agree	Strongly Agree	Strongly Agree	
12			Excellent	Neutral	insert add option	Strongly Agree	Strongly Agree	Neutral	Strongly Agree	
13			Good	Agree	add more options	Agree	Agree	Agree	Neutral	
14			Satisfactory	Agree	Add more features	Agree	Strongly Agree	Neutral	Agree	
15			Good	Neutral	Improve user interaction	Agree	Agree	Agree	Agree	
16			Satisfactory	Strongly Agree	Need huge improvement on it	Neutral	Strongly Agree	Neutral	Neutral	
17			Good	Neutral	Improve more	Neutral	Neutral	Agree	Neutral	
18			Good	Disagree	more improvement needs	Disagree	Disagree	Disagree	Agree	
19			Excellent	Agree	improve performace	Agree	Strongly Agree	Neutral	Disagree	
20			Satisfactory	Neutral	improve interface	Neutral	Neutral	Neutral	Neutral	

Fig. 11: Feedback Form Result

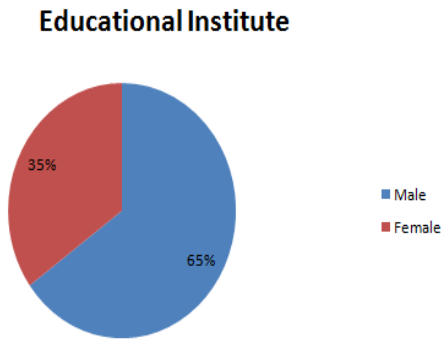


Fig. 12: Graphs showing Male% and Female% in Educational Institute

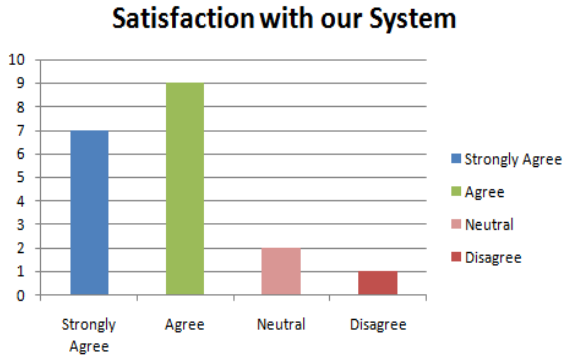


Fig. 14: Graphs showing Satisfaction with our System

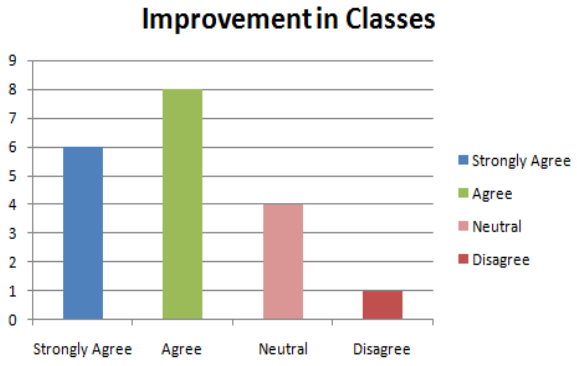


Fig. 13: Graphs showing Improvement in Classes

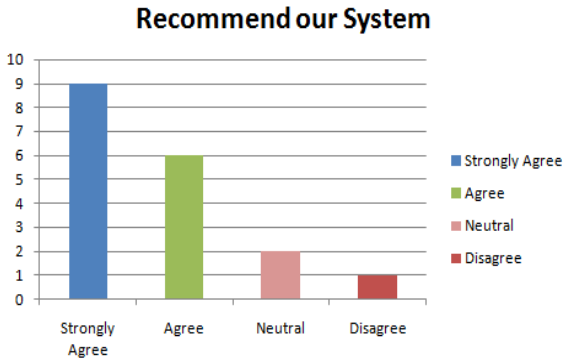


Fig. 15: Graphs showing customer feedback on whether they will recommend our system further or not

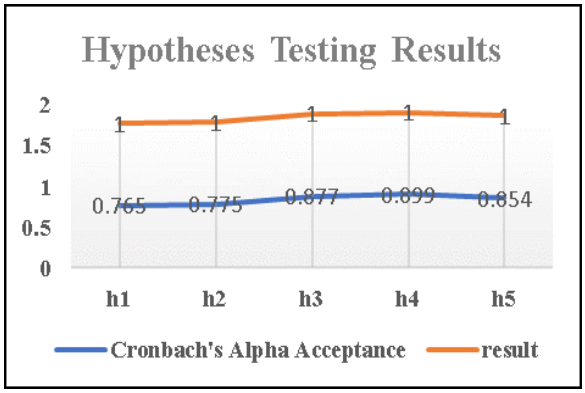


Fig. 16: Hypotheses Testing Results

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