

Software Engineering Department  
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Capstone Project Phase A – 61998

**Adaptive Student Arrangement System for Enhanced Learning**

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**Abstract**

In today’s diverse educational settings, effective classroom management requires a strategic approach that considers students' backgrounds, language proficiency, social needs, and learning challenges such as ADHD. This project aims to develop an optimal classroom setup by integrating decision trees with a Constraint Satisfaction Problem (CSP) algorithm, informed by teacher input.

Traditional seating arrangements often fail to accommodate the varied needs of modern classrooms. To address this, we will collect comprehensive data on students, including their school levels, behavior, special needs, and teacher insights. This data will be used to build a decision tree that identifies key factors for student grouping, followed by the application of a CSP algorithm to create effective seating arrangements that meet all defined constraints.

The system will be refined iteratively, incorporating continuous feedback from teachers to ensure the seating arrangements are practical, flexible, and adaptive. A weighting system will also be applied to prioritize the most critical factors, ensuring that the most important aspects are given appropriate attention in the seating arrangement process.

Our primary objective is to enhance student performance by creating adaptable classroom environments that optimize learning outcomes and social interactions. By employing decision trees and CSP algorithms, and integrating real-time feedback from teachers, we aim to develop a system that effectively meets the diverse needs of students and lays a strong foundation for future improvements.

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4. **Introduction**

In the evolving landscape of 21st-century education, classrooms are becoming increasingly inclusive and diverse[1]. This shift presents educators with the complex challenge of organizing students in ways that optimize both learning opportunities and social interactions. Traditional methods of student placement often fall short in accommodating the wide range of needs and backgrounds[2] present in today's educational settings, including differences in educational background, language proficiency, social-emotional motivation, and various learning needs, such as attention-deficit hyperactivity disorder (ADHD)[3]. Inadequately addressing these factors can result in suboptimal learning conditions, ultimately diminishing the educational experience for many students.

An effective classroom layout is crucial for fostering an environment conducive to student success. Research indicates[4] that strategic seating arrangements can significantly impact student engagement, peer interactions, and overall school achievement. For example, grouping students based on compatible skills can facilitate peer learning, while aligning students with similar needs can enhance the effectiveness of targeted instructional strategies. However, the manual process of organizing such arrangements is time-consuming and prone to errors, necessitating a systematic, data-driven approach.

This project proposes the development of an adaptive system for student seating arrangements, leveraging decision trees[5] and teacher preferences to dynamically organize students. This Quality Assurance Agency (QAA)[6] approach incorporates multiple criteria related to students' educational backgrounds, language proficiency, sociocultural contexts, and individual profiles, aiming to create classroom environments that support both learning and socialization.

The project will be implemented in phases, beginning with a comprehensive literature review to explore the impact of various student compositions on learning outcomes and peer performance. This review will be complemented by demographic data, needs-based information, and feedback from teachers and educational experts. The gathered information will inform the development of a decision tree model, which will be iteratively refined based on input from educators.

Ultimately, this project seeks to enhance classroom arrangements, thereby improving educational outcomes. The resulting system is expected to holistically prepare learning spaces, ensuring that classroom layouts are tailored to the diverse needs of students.

**1.1 Planned Solution**

The central focus of our project is the development of an intelligent system akin to a Virtual Classroom, designed to optimize student placement based on educational background, learning level, attitudes, and social needs. This system will manifest as an Intelligent Seating System that leverages decision tree algorithms and Constraint Satisfaction Problem(CSP)[7] techniques to generate the most effective seating arrangements and student groupings. The system will feature dynamic seating designs based on real-time data and teacher preferences, creating personalized groupings that strike a productive balance between student strengths and weaknesses. Additionally, it will utilize data-analytics-derived behavioral insights to predict and understand student behavior, ensuring a conducive learning environment. Importantly, the system will include inclusive designs that accommodate students with special needs, different mother tongues, and those who are new immigrants. This innovative approach aims to enhance student engagement by developing optimal seating arrangements, leading to improved learning outcomes in a differentiated classroom setting. Furthermore, it promotes a more inclusive and supportive classroom management strategy, ensuring every student has an equal opportunity to succeed.

**1.2 Benefits**

This Intelligent Seating System offers a wide range of benefits across the educational system. Teachers will gain access to new insights derived from real-time data, allowing for more informed classroom management and the ability to regularly update seating arrangements based on evolving student needs. Students will experience personalized learning sessions tailored to their individual needs, which can enhance engagement, foster social interactions, and contribute to both academic and personal growth. Parents will benefit from improved communication, gaining a clearer understanding of their child's learning environment and school progress, thereby strengthening the connection between school and home. School administrators will have access to robust student outcomes data, enabling evidence-based policy-making and interventions that promote more effective teaching and learning practices. Additionally, the system will provide educational researchers with valuable data on best practices for classroom management, while also offering policymakers insights that can guide informed decisions to improve classroom conditions and overall student outcomes. Overall, the system aims to create a more inclusive, dynamic, and supportive educational atmosphere that benefits all involved.

**2. Related Work**

Understanding the impact of classroom seating arrangements on student behavior, engagement, and school performance has been the subject of considerable research. These studies provide insights into how different configurations can either enhance or impede student interaction and learning outcomes. The following sections explore various research contributions that underscore the importance of flexible and adaptive seating arrangements in modern educational environments.

The arrangement of students within a classroom significantly impacts their ability to engage with the material, participate in class, and feel comfortable among their peers. Traditional seating arrangements, such as rows or clusters, often lack the flexibility required to meet the diverse needs of modern classrooms. These static setups can hinder student interaction, exacerbate behavioral issues, and neglect students who require special educational attention. Educational research supports the notion that flexible and adaptable classroom environments are crucial for addressing the varying learning needs of students [8].

Numerous studies have highlighted the significant influence that seating arrangements can have on student engagement, behavior, and overall school performance [8][9]. Research indicates that different seating configurations can lead to varying levels of student participation and focus. For instance, when students are seated in groups rather than in traditional rows, they tend to engage more actively in classroom discussions and remain more focused on their schoolwork. Group seating promotes not only school success but also social gains, as it encourages interactions among peers, both within social and non-social clusters. In contrast, traditional row seating often fosters a more passive learning environment, making it harder for students to engage and support one another. These findings underscore the need for adaptive seating arrangements that can automatically generate configurations that encourage student interaction and enhance educational experiences during class time [10].

Inclusive education is grounded in the belief that all students, regardless of their social, political, or economic backgrounds, have the right to a quality education that meets their diverse learning needs. This principle extends to students with unexpected learning needs, special educational requirements, and learning disabilities. Research supports the idea that adaptive seating arrangements can provide these students with an equitable learning environment[11]. Proper classroom placements can minimize interruptions, offering students a conducive setting for successful learning. Adaptive systems can be designed to create customized seating plans that cater to individual student needs, promoting inclusive practices that enhance the overall classroom atmosphere. These systems also have the potential to generate valuable data, helping teachers better understand individual student needs and offer more personalized support [12].

The integration of technology in education has proven effective in enhancing classroom settings. The power of modern digital tools, combined with advanced research on personalized learning and optimized classroom configurations, is immense. For example, decision tree-based systems can analyze factors such as student demographics, educational backgrounds, and learning needs to recommend optimal seating assignments. By leveraging technology, teachers can create more interactive and adaptive classroom experiences that enrich student participation and foster collaborative learning outcomes. Adaptive systems offer the potential for highly optimized and personalized learning experiences through the use of data and technology. Furthermore, these systems can provide real-time personalization in education, ensuring that classroom environments are continuously tailored to the evolving needs and dynamics of students [13].

**2.1 Existing Tools and Methods**

#### A variety of current solutions are designed to optimize classroom utilization and enhance student engagement and learning outcomes. Digital seating chart systems, such as SmartSeat[14] and ClassChart[15], empower teachers to create and adjust classroom layouts based on students' school and behavioral needs. Additionally, classroom behavior management platforms like ClassDojo[16] provide valuable insights into student behavior and engagement, enabling educators to design seating and group arrangements that foster a more conducive learning environment. While these tools offer significant advantages in managing classroom dynamics, there remains a pressing need for a more integrated solution that seamlessly connects and optimizes both the physical and behavioral aspects of the classroom environment.

#### 2.1.1 ClassCharts

ClassCharts is a digital tool designed to help teachers create and manage seating arrangements. It allows educators to visually organize students for seating assignments using both school and behavioral data. The platform enables easy customization, allowing teachers to rearrange seating by simply dragging and dropping student names, and adjusting layouts to suit different classroom activities.

**2.1.1.1 Features**

**Customizable Seating Plans:** Teachers can design and modify seating plans tailored to specific tasks, group work, or other classroom activities.

**Behavior Tracking:** ClassCharts includes behavior tracking features, enabling teachers to monitor and log student behavior, assign points for positive actions, and note any negative behavior.

**Integration with School Management Systems:** The tool can be integrated with various school management systems, ensuring student information remains synchronized across platforms.

**2.1.1.2 Limitations**  
Despite its advantages, ClassCharts lacks the ability to automatically adjust seating arrangements in real-time based on ongoing data. Teachers must manually update seating plans, which can be time-consuming and may not always reflect the most current student needs and interactions.

**2.1.1.3 Achievements**

1. Schools rated as "Requires Improvement" by Ofsted for personal development, behavior, and welfare saw their ratings improve to "Good" after implementing ClassCharts.
2. Schools have reported a 400% increase in achievement points after adopting ClassCharts, highlighting its ease of use.
3. At Acklam Grange School, fixed-term exclusions were reduced from four per week to just two in total for the entire year after using ClassCharts.
4. For a teacher with 10 classes, changing seating plans once per term results in significant time savings, which are further enhanced when combined with behavior management features.

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**2.1.2 SmartSeat**

SmartSeat is a mobile application designed to streamline the process of creating and managing classroom seating arrangements for teachers. With its intuitive and flexible interface, the app allows educators to adjust student seating to enhance both school and behavioral performance. SmartSeat offers a comprehensive classroom management solution that goes beyond seating charts, incorporating features such as attendance tracking and student note-taking.

**2.1.2.1 Features**

**Drag-and-Drop Seating:** Teachers can easily create seating charts by dragging and dropping student names into new positions. This feature allows for quick adjustments, enabling educators to respond promptly to changes in classroom dynamics or individual student needs.

**Attendance Tracking:** The app handles attendance tracking directly on the seating chart interface, saving time and providing a visual representation of student attendance. By identifying visible attendance patterns, teachers can more effectively address related issues.

**Student Note-Taking:** Teachers can add notes for individual students directly on their seats. These notes can document specific behavioral issues, track how absences impact school progress, or highlight other important details shared by students or parents. This feature offers valuable insights that can inform seating adjustments and other classroom management decisions.

**Customizable Seating Plans:** Teachers can create multiple seating plans for each class, tailored to different activities or periods. For example, a seating plan for lecture-based learning might differ from one designed for group work. This flexibility allows educators to adapt the classroom environment to support various teaching styles and activities.

**2.1.2.2 Limitations**  
Although SmartSeat provides useful features for classroom management, it lacks seamless real-time data integration and advanced analytics. Teachers still need to manually update seating arrangements and observations, which can be time-consuming. Additionally, SmartSeat does not dynamically adjust seating based on continuous data collection or changes in student behavior and performance.

Overall, SmartSeat is a promising classroom management tool that simplifies the setup and maintenance of effective learning environments. However, its reliance on manual updates and the absence of real-time data integration highlight the need for more advanced solutions. A Virtual Classroom concept, where seating arrangements automatically adapt using decision tree algorithms and real-time data, represents a potential evolution in classroom management technology.

**2.1.3 ClassDojo**  
ClassDojo is a free behavior management app designed for teachers to engage with students and parents. The platform integrates behavior tracking with interactive mini-games, creating an engaging environment for students. ClassDojo is widely used in classrooms to build a sense of community and support student learning.

**2.1.3.1 Features**

**Behavior Tracking:** ClassDojo employs a real-time point system that allows teachers to monitor student behavior. Points can be awarded for positive behaviors like teamwork, persistence, and participation, or deducted for negative behaviors. This system encourages best practices and provides students with immediate feedback on their progress.

**Parent Communication:** The app includes tools for teachers to share classroom updates, photos, and videos directly with parents. This feature promotes greater parental involvement in their child’s education, fostering a strong partnership between home and school.

**Student Portfolios:** Students can create digital portfolios within ClassDojo to showcase their work and track their learning over time. These portfolios allow students to reflect on their progress and share their achievements with teachers and parents. Portfolios can include photos, videos, and written work, offering a comprehensive view of a student’s educational journey.

**Educational Resources:** ClassDojo provides a variety of resources, including activities and lesson plans focused on social-emotional learning (SEL)[17]. Incorporating SEL into daily routines helps students develop essential emotional and interpersonal skills.

**2.1.3.2 Limitations**  
ClassDojo has faced criticism, particularly regarding data privacy. The platform tracks and shares personal information not only with teachers but also with third parties, raising concerns about data security. Ensuring that this information is protected is crucial for maintaining user trust and preventing potential data breaches.

**2.1.3.3 Achievements**  
ClassDojo enhances classroom culture by reinforcing positive behaviors and improving communication. The platform offers real-time feedback and rewards students for forming good habits and achieving milestones, providing instant gratification. Enhanced communication tools and digital student portfolios help engage parents more actively in their child's learning.

In addition, ClassDojo emphasizes social-emotional learning, helping students cultivate key skills like empathy, resilience, and collaboration, which are crucial for both school success and overall well-being.

**3. Expected Achievements**

**3.1 Outcomes**  
The project aims to develop a virtual classroom arrangement system that enables teachers to organize students based on factors such as school background, language proficiency, and social dynamics using a decision tree algorithm, visualized through a tool like a 35x35 matrix. Expected outcomes include improved student engagement and learning, enhanced teacher effectiveness and satisfaction, and the ability to create more personalized learning environments. Success will be measured by better student outcomes, positive teacher feedback, high adoption rates, and scalability to accommodate large numbers of students using available educational resources.

**3.2 Unique Features**  
**3.2.1 Dynamic Visualization Tool**  
A visual interface, configurable to different classroom layouts, such as an XxY matrix, that displays student arrangements in real-time. This flexibility allows teachers to easily understand and manage groupings, whether the classroom has tables for one, two, or more students.

**3.2.2 Teacher Preferences Integration**  
The algorithm incorporates teacher preferences and insights, allowing the system to suggest personalized, experience-based adjustments to student placement.

**3.2.3 Individualized Decision Tree Algorithms**  
Customized decision trees for each student, designed to address both academic and social needs.

**3.2.4 Support for Diverse Student Needs**  
The system accommodates students with varying language backgrounds, recent arrivals, and those with special educational needs, including ADHD.

**3.2.5 Scalability and Flexibility**  
The system is adaptable to different class sizes and can be scaled to manage multiple classrooms.

**3.3 Criteria for Success**

- Improved student school performance, reflected in better grades and attendance.

- High usability and effectiveness, leading to increased teacher satisfaction.

- Widespread adoption among teachers, making the system more practical and widely accepted.

- Successfully implemented customized groupings tailored to individual student needs.

- Scalable and adaptable to different class sizes and educational settings.

**4. Engineering Process**

**Motivation and Rationale**  
This project aims to create an efficient virtual classroom seating arrangement system that fosters an inclusive and supportive learning environment. By considering factors such as students' backgrounds, behaviors, special needs, language skills, and social dynamics, we aim to enhance school performance, behavioral outcomes, and teacher-student interactions through well-designed seating arrangements.

**4.1 Initial Research and Data Collection**

**Objective:** Gather comprehensive information on each student to optimize seating arrangements.

**Steps Taken:**

**Literature Review:** Analyzed existing tools like SmartSeat, ClassDojo, and others. to understand current seating arrangement methods and identify gaps where our approach can provide improvements.

Surveys and Interviews: Developed custom surveys and planned in-person interviews with students at the school. The goal of these interviews is to collect data on various aspects of the students’ school and social experiences that influence their seating preferences.

**Student Seating Preferences Questionnaire**

**Section 1: Comfort and Focus**

**Preferred Seating Location:**

* + Where do you like to sit in the classroom? (For example: front, middle, back, near windows, near the door)
  + Why do you like sitting there?

**Focus and Concentration:**

* + Do you find it easier to focus when you sit in a specific part of the room? If yes, where?
  + Are there places in the classroom where you find it harder to concentrate?

**Section 2: Peer Interaction**

**Seating with Friends:**

* + Do you prefer sitting next to your friends, or do you focus better when sitting with other classmates?
  + When we do group activities, do you like to be with your friends, or do you prefer being in a group with different students?

**Section 3: Behavior and Participation**

1. **Class Participation:**
   * Does where you sit in the classroom affect how much you participate in class activities or discussions?
   * Are there certain spots in the classroom where it’s harder for you to stay on task?

**Section 4: Special Needs**

**Comfort and Support:**

* + Is there anything special you need in your seating arrangement to help you feel comfortable and do your best in class? (For example: sitting close to the teacher, needing a special chair)
  + Do certain seating arrangements make it easier for you to learn?

**Section 5: Language Proficiency**

**Language Support:**

* + Do you speak a language other than English at home?
  + Is it easier for you to learn when you sit with classmates who speak the same language?
  + Would you like to sit with students who can help you practice speaking English, or would you prefer sitting with those who speak your home language?

**Section 6: General Preferences and Observations**

**General Thoughts:**

* + Where do you think you learn best in the classroom?
  + Is there anything else you want to tell me about where you sit in class?

**4.2 Algorithm Development and Implementation**  
The goal is to develop an algorithm that generates the optimal seating arrangement for each classroom.

**4.2.1 Steps Taken:**

* **Decision Tree Algorithm:** Designed the algorithm based on the criteria defined by the decision tree, incorporating weighted factors.
* **Proof of Concept:** Established a proof of concept by creating an initial version of the algorithm.
* **Initial Testing:** Conducted a small-scale testing phase to identify and resolve bugs, ensuring the tool functions as intended.

**4.2.2 Future Steps:**

* **Classroom Testing:** Run the tool in selected classrooms to assess its effectiveness and gather user feedback.
* **Iterative Improvement:** Continuously refine the algorithm and user interface based on insights from pilot testing.

**5. Product**

**5.1 Proposed Methodology for Virtual Classroom Arrangement**  
To effectively arrange students in a classroom according to their individual needs, a structured approach considering various factors is essential. Our methodology outlines key criteria to be assessed for each student and the strategy for grouping them.

**5.1.1 Educational Background and School Level**

**Assessment:** Evaluate each student's school abilities through testing, past grades, and teacher recommendations.

**Grouping:** Decide whether to group students with similar school levels (homogeneous grouping) for targeted instruction or mix different levels (heterogeneous grouping) to promote peer learning and support.

**5.1.2 Behavior and Social Skills**

**Behavioral Considerations:** Identify students with behavioral needs (e.g., ADHD) who may require specific seating, such as closer proximity to the teacher or avoiding distractions like windows.

**Interpersonal Skills:** Assess students' group work, communication abilities, and concentration to ensure positive peer interactions by placing compatible students together.

**Special Needs and Accommodations:** Account for any physical, sensory, or learning disabilities requiring accommodations. For instance, a student with poor vision should sit at the front, while a student using a wheelchair needs easily accessible seating.

**Accessibility:** Ensure seating arrangements comply with accessibility guidelines, allowing all students to participate fully.

**Language Proficiency:** Group students based on language skills, placing English language learners with peers who can support their social and school integration.

**Social Dynamics:** Consider friendships and potential conflicts when organizing seating. Strategically group students who collaborate well together while minimizing negative interactions.

**Peer Influence:** Position positive role models with students who could benefit from their guidance to foster a productive learning environment.

**5.2 Requirements**

**Functional:**

|  |  |
| --- | --- |
| **1** | The system must collect data on students' school levels, behavior, special needs, language proficiency, and social dynamics |
| **2** | The system must allow for weighting of different criteria based on their importance in the classroom context |
| **3** | The system must implement a decision tree algorithm to determine optimal seating arrangements |
| **4** | The system must allow teachers to input and update student data. |
| **5** | |  | | --- | |  |  |  | | --- | | The system must provide a mechanism for teachers to give feedback on the  seating arrangements. | |
| **6** | The system must allow for dynamic adjustments to seating arrangements based on feedback and changing needs. |
| **7** | The system must generate reports on seating arrangements and their effectiveness. |
| **8** | The system must ensure the confidentiality and security of student data. |

**Non – Functional:**

|  |  |
| --- | --- |
| **1** | The system must be easy to use and have an intuitive user interface. |
| **2** | The system must process data and generate seating arrangements quickly. |
| **3** | The system must be able to handle an increasing number of students and classrooms. |
| **4** | The system must be reliable and consistently perform as expected. |
| **5** | The system must be easy to maintain and update. |
| **6** | The system must comply with relevant data protection and education standards. |

#### 5.3 Algorithm

**5.3.1 Data Collection**

The system gathers key data about each student from the teacher, focusing on four main factors:

* **School Performance**: The student’s ability to understand and apply concepts in core subjects, as reflected by test scores, classwork, and teacher evaluations.
* **Behavioral Challenges**: The student’s behavior in the classroom.
* **Social Preferences**: Whether the student prefers group work or working individually.
* **Special Needs**: Any additional support or accommodations required.

**5.3.2 Decision Tree with Scores and Weight Percentages**

Each node in the Decision Tree has a **score (1, 2, or 3)** based on the student’s characteristics, and each factor has an assigned **weight percentage** based on its importance in the seating arrangement.

**Nodes and Scoring System:**

1. **School Performance (20%)**:
   * High performance → **3 points**
   * Medium performance → **2 points**
   * Low performance → **1 point**
2. **Behavioral Challenges (30%)**:
   * Disruptive → **3 points**
   * Moderate → **2 points**
   * Well-behaved → **1 point**
3. **Social Preferences (20%)**:
   * Needs specific seating/grouping → **3 points**
   * Flexible but prefers groups → **2 points**
   * Flexible, prefers individual work → **1 point**
4. **Special Needs (30%)**:
   * High level of support needed → **3 points**
   * Moderate support needed → **2 points**
   * No special needs → **1 point**

based on general classroom management and seating research[18]:

1. **Behavioral Challenges (30%)**: Behavior plays a critical role in seating decisions, as disruptive behavior can hinder the learning environment for both the student and their peers. Behavioral management, including seating placement, has been shown to improve focus and reduce distractions. Therefore, I assigned a higher weight (30%) to reflect its impact on the classroom atmosphere​
2. **Special Needs (30%)**: Students with special needs, such as visual, auditory, or learning disabilities, require specific accommodations. Research supports the notion that seating arrangements for these students can significantly improve their ability to engage with the material, thus earning a high weight (30%)​
3. **School Performance (20%)**: While important, school performance often benefits from peer collaboration and support. Research shows that seating students based on their school level can foster learning, though the immediate impact may not be as strong as behavior or special needs. Hence, I assigned this a medium weight (20%).
4. **Social Preferences (20%)**: Social compatibility helps with group work and classroom collaboration. It is important for the overall class dynamic but has a relatively lower immediate impact on individual school outcomes, thus a medium weight (20%).

**5.3.3 Calculating Total Weight**

To calculate the total weight for each student, multiply the points by the corresponding percentage for each factor, then sum them to get the final weight.

**Example Calculation for Student A:**

* **High School Performance** → 3 points × 20% = **0.6**
* **Moderate Behavioral Challenges** → 2 points × 30% = **0.6**
* **Needs Specific Social Grouping** → 3 points × 20% = **0.6**
* **No Special Needs** → 1 point × 30% = **0.3**

**Total Weight for Student A**:  
0.6+0.6+0.6+0.3=2.1

**5.3.4 CSP Algorithm**

The **CSP algorithm** takes the total weight for each student and assigns seats based on these weights, while adhering to the following constraints:

* **Behavioral Constraints**: Disruptive students should not sit next to each other.
* **Special Needs Constraints**: Students with special needs should sit near the teacher or front of the classroom.
* **School Constraints**: High-performing students can sit in central or front seats for better focus.
* **Social Constraints**: Group-oriented students should be seated with peers who enhance their learning.

**5.3.5 CSP Execution**

1. **Assign Seats**: Start with students who have the highest total weight, placing them in the most appropriate locations based on their needs.
2. **Arc Consistency (AC-3)**: Ensure that the seating assignment satisfies all constraints by checking the possible domain for each student.
3. **Backtracking**: If conflicts arise, backtrack and try different seating assignments.

### **5.3.6 Output - Seating Arrangement as an X\*Y Matrix**

After running the **CSP Algorithm** and applying the constraints, the seating arrangement is presented as an **X\*Y matrix**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| |  | | --- | | Row/Column |  |  | | --- | |  | | 1 | 2 | … | Y |
| 1 | Student A | Student B | … | Student Y |
| 2 | Student Y+1 | Student Y+2 | … | Student 2Y |
| … | … | … | … | …. |
| X | Student (X-1)Y+1 | Student (X-1)Y+2 | … | Student XY |

#### 5.4 Evaluating Classroom Performance Through Seating Arrangement Adjustments

When evaluating the effectiveness of a seating arrangement and how it impacts classroom dynamics, several factors should be assessed both **before** and **after** making changes. Based on educational research[18], the most relevant factors include:

1. **School Performance**:
   * **Before**: Record students' grades and participation in activities.
   * **After**: Check for improvements in performance, such as higher test scores, better participation, and faster completion of tasks.
2. **Classroom Engagement**:
   * **Before**: Observe the level of student engagement in lessons (e.g., participation in discussions, staying on task).
   * **After**: Compare with how students interact post-seating change to see if they are more attentive or involved.
3. **Behavioral Incidents**:
   * **Before**: Track any behavioral issues such as disruptions or students being off-task.
   * **After**: Evaluate whether the new arrangement has reduced negative behaviors and improved overall classroom management.
4. **Social Interactions**:
   * **Before**: Monitor how well students collaborate and interact with peers.
   * **After**: Check if social dynamics have improved, particularly during group work or peer activities.
5. **Student Comfort**:
   * **Before**: Assess how comfortable students feel in their assigned seats, which may impact focus and attention.
   * **After**: Ask for feedback on whether students feel more comfortable and engaged in their new seating positions.
6. **Teacher Feedback**:
   * **Before**: Collect the teacher's insights on classroom management and student progress.
   * **After**: Gather post-seating feedback to see if the arrangement has improved the teacher’s ability to manage the classroom effectively.

#### Based on educational research[19], a ****mid-term evaluation period**** of ****1 to 2 months**** after the seating arrangement change is recommended as the most reliable timeframe for checking improvements. This period allows enough time for students to adjust to their new seating positions and for the effects on ****school performance, behavior, and social interactions**** to become evident​

#### 5.5 Technology Stack

**1. Frontend:**

**React.js:** React.js is a popular JavaScript library for building fast, dynamic, and responsive user interfaces. It offers component-based architecture, making it easier to manage and reuse code. React’s virtual DOM improves performance, and its state management simplifies dynamic data updates, making it ideal for modern web applications.

**2. Backend:**

Node.js with Express.js: Node.js is widely adopted and easier to set up

Key Features: Handles routing, middleware, and API management with minimal setup.

**3. Database:**

MongoDB: is an ideal choice due to its flexibility, scalability, and ability to efficiently handle diverse, unstructured data types like student profiles and adaptive seating arrangements.

**4. Development & Deployment:**

Git/GitHub: essential for version control and collaboration.

Node.js for Deployment

**5. Tools & Extensions:**

* **Admin Interface with React.js**: The admin dashboard will be built using **React.js** to create dynamic, reusable components and a more interactive user experience, connecting to the backend via API.
* **Security and Authentication**: **React.js** will work with backend tools like **Passport.js** for user authentication, handling secure login, session management, and access control using token-based authentication.

**Summary:**

 **Frontend**: **React.js** – A modern JavaScript library for building dynamic user interfaces with reusable components and efficient rendering.

 **Backend**: Node.js with Express.js

 **Database**: MongoDB with Node.js

 **Deployment** : Vercel with Git for version control

**5.5.1 Teacher Features**

**Data Input and Management:**

**Add Student Information:** Teachers can enter data for each student, including school performance, behavior, special needs, language skills, and social interactions.

**Edit Student Information:** Teachers can update or modify student information as needed.

**Bulk Data Upload:** Allows teachers to upload CSV or Excel files for efficient bulk data input.

**Grouping and Seating Arrangement:**

**Generate Initial Grouping:** Teachers can use the system to automatically create initial student groups based on a Decision Tree algorithm.

**View and Adjust Groups:** Teachers can review the algorithm-generated groups and make manual adjustments if required.

**Generate Seating Arrangement:** The system creates a seating plan based on the final groups.

**Feedback and Iteration:**

**Approve or Reject Seating Arrangements:** Teachers can either approve the suggested seating plan or request a new one if the current arrangement doesn’t meet their needs.

**Provide Feedback:** Teachers can offer feedback to improve the algorithm for future arrangements.

**Small Tests and Assessments:**

**Create and Assign Tests:** Teachers can design small quizzes or tests to evaluate students’ school levels and social skills.

**Analyze Results:** The system analyzes test results and integrates them into student profiles to enhance future groupings.

**5.5.2 System Windows**

**Dashboard:**

Overview of student data and quick access to key features (e.g., adding students, generating groups).

**Student Management:**

**Add/Edit Student:** A form for adding or editing individual student details.

**Bulk Upload:** Interface for uploading student data via CSV/Excel files.

**Grouping and Arrangement:**

**View Groups:** Display of current student groups with options to edit or rearrange them.

**Generate Seating Arrangement:** Button to create seating plans based on the groups.

**Seating Arrangement:**

**View Seating Plan:** Visual representation of the seating arrangement.

**Approve/Reject:** Buttons for approving or rejecting the seating plan.

**Provide Feedback:** A text box for teachers to give feedback on the seating arrangement.

**Test and Assessment:**

**Create Test:** Form for designing new tests.

**Assign Test:** Interface for assigning tests to students or groups.

**View Results:** Display and analysis of test results.

**Settings and Preferences:**

**User Preferences:** Options to customize the system interface and notification settings

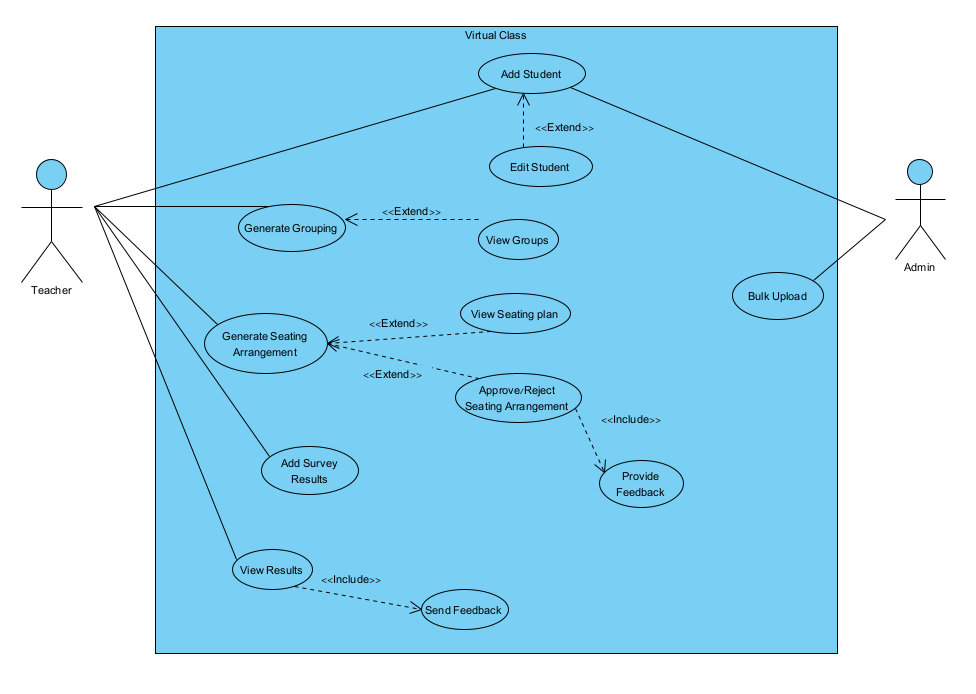
**5.6 Our Solution for Optimal Classroom Seating Arrangements**

After researching effective methods for optimizing classroom seating arrangements, without relying solely on traditional approaches, we believe that a personalized system is required—one that is designed specifically to meet the needs of each student. Our solution involves the integration of decision trees with a Constraint Satisfaction Problem (CSP) algorithm, enhanced by the AC-3 (Arc Consistency) algorithm and real-time teacher feedback.

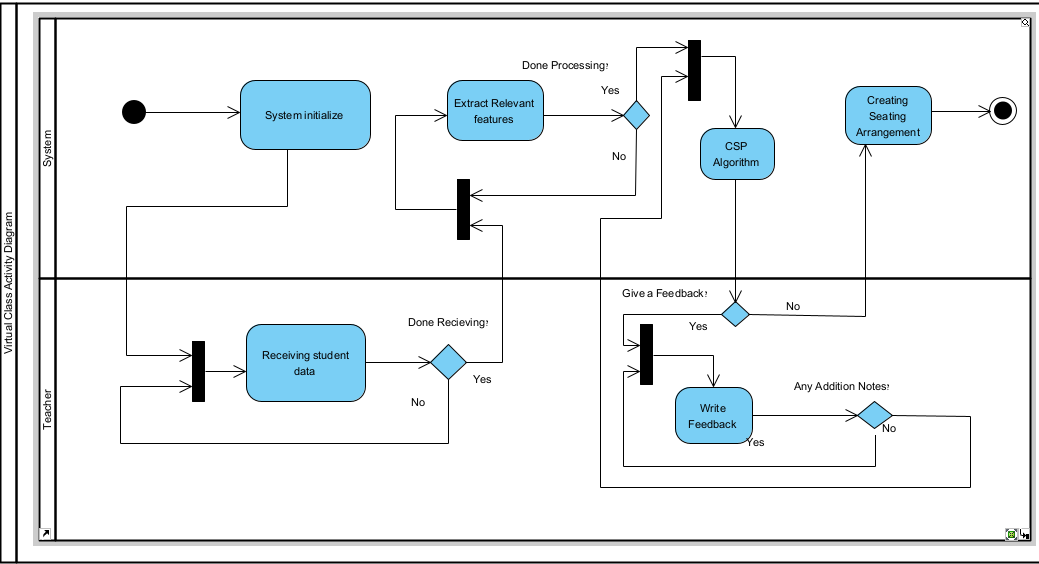
The methods mentioned above can improve seating arrangements significantly. By designing a system that analyzes student data, including educational background, behavior, social skills, and special needs, we can create seating plans that foster both academic and social success. By incorporating teacher preferences and continuous feedback, the system can dynamically adjust seating configurations, ensuring that each student is positioned to maximize their potential.

Our software will be designed in such a way that teachers, and educators in general, will be able to input data on student attributes, and the software will generate an optimized seating arrangement. The system will apply the AC-3 algorithm to enforce consistency across constraints and allow for adjustments based on real-time feedback, ensuring that the seating plan remains effective throughout the school term. The software will also provide detailed reports on the effectiveness of the seating arrangement, offering insights that can help further refine the process.

We believe that developing such a user-friendly system and implementing it in classrooms can fundamentally enhance the educational experience, addressing the diverse needs of students more effectively than traditional methods.

**5.7 Use Case Diagram**

**5.8 Activity Diagram**



**5.9 Database Structure**

**Entities:**

1. **Student**
   * Attributes: StudentID, FirstName, LastName, DateOfBirth, Gender, GradeLevel, LanguageProficiency, SpecialNeeds, ParentContact.
   * Relationships: EnrollsIn (Classes), TakesTest (Assessments).
2. **Teacher**
   * Attributes: TeacherID, FirstName, LastName, SubjectSpecialization, Email, PhoneNumber.
   * Relationships: Teaches (Classes).
3. **Class**
   * Attributes: ClassID, ClassName, Schedule, Location, TeacherID.
   * Relationships: HasStudents (Students), HasTests (Assessments).
4. **Test/Assessment**
   * Attributes: TestID, TestName, TestDate, MaxScore, Duration, ClassID.
   * Relationships AdministeredTo(Students), ScoredBy (Teacher/System).
5. **Seating Arrangement**
   * Attributes: SeatingID, ClassID, ArrangementData.
   * Relationships: AppliesTo (Students)

**6. Acceptance Test**

|  |  |  |  |
| --- | --- | --- | --- |
| **Test** | Module | Tested Function | Expected Result |
| 1 | Decision Tree Algorithm | Student Grouping by Educational Background | Students with similar educational backgrounds are grouped together appropriately. |
| 2 | CSP Algorithm | Constraint Satisfaction Problem Solver | Seating arrangements meet all defined constraints without conflicts. |
| 3 | Virtual Classroom Interface | Dynamic Seating Arrangement Update | Seating layout is updated dynamically based on real-time data, teacher inputs, and changes in student needs. |
| 4 | Data Analytics Module | Behavior Insights Prediction | Accurate prediction and visualization of student behavioral trends based on input data. |
| 5 | Accessibility Features | Inclusive Design Implementation | Students with special needs are placed in positions that accommodate their requirements effectively. |
| 6 | Teacher Preferences Integration | Custom Seating Arrangement | Teacher-defined seating preferences are accurately applied in the seating plan. |
| 7 | Real-Time Updates | Live Student Positioning | Seating arrangements adjust in real-time as new data is provided, allowing dynamic adjustments based on feedback. |
| 8 | Data Import Module | Import of Student Data | Student data on school levels, behavior, special needs, language proficiency, and social dynamics is accurately imported into the system from external sources. |
| 9 | User Interface | Show Seating Arrangement | The system displays the current seating arrangement clearly and accurately, allowing teachers to review and assess the configuration. |
| 10 | User Interface | Update Seating Arrangement | Teachers can easily update and modify the seating arrangement based on new data or feedback, with changes reflected in real-time. |
| 11 | User Interface | User Navigation and Interaction | The interface is intuitive, and users can easily navigate, input, and update student data, as well as modify seating arrangements. |
| 12 | Security | Data Privacy and Protection | Student data is secure and not accessible by unauthorized users, ensuring confidentiality and security. |
| 13 | Reporting | Reports Generation | The system generates reports on seating arrangements and their effectiveness, providing valuable insights for teachers. |
| 14 | System Performance | Response Time Under Load | The system remains responsive and updates seating arrangements promptly under varying load conditions. |
| 15 | Error Handling | Invalid Input Detection | The system appropriately handles invalid input data and provides meaningful error messages to the user. |
| 16 | Logging | Activity Logging | The system logs all user activities, ensuring accountability and tracking for later review. |

**7. AI Tools:**

**Chatgpt:**

<https://chatgpt.com/>

We used ChatGPT, an AI tool, to help with our classroom seating arrangement project. ChatGPT provided guidance on the algorithm, helped organize our thoughts, and even assisted with writing parts of the documentation. Below are the key prompts we used and how ChatGPT helped:

**Describing Our Project:**

* **Prompt:** We described our project, explaining the need for seating students based on different criteria.
* **ChatGPT’s Help:** It organized our project into clear steps and helped refine our algorithm.

**Improving the Algorithm:**

* **Prompt:** We asked for more details on how to build and use a Decision Tree in our algorithm.
* **ChatGPT’s Help:** It explained how to create the Decision Tree, how it works, and what to save in our database.

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