RAJSHAHI UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Computer Science and Engineering

Information System Analysis and Design
of
CHORCHA
An EdTech Platform

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Table of Contents

Chapter 1

Recognition of Need

Figure 1.1: Chorcha Logo

1.1 Introduction

Chorcha is a leading EdTech company and Bangladesh's finest problem-solving and exam preparation site. Founded with the vision of democratizing quality education, Chorcha has established itself as a premier platform for academic excellence and skill development.

Company Vision:

To become the most trusted and accessible educational technology platform in Bangladesh, empowering every student with personalized learning experiences and innovative study materials that bridge the gap between traditional education and modern digital learning methodologies.

Company Mission:

To empower students with their optimum academic achievement through innovative study materials, comprehensive assessment tools, and a supportive online community that fosters collaborative learning and continuous improvement in academic performance.

Chorcha's flagship is a comprehensive web and mobile application platform featuring systematic mock tests, extensive question banks, previous year exam questions, and AI-based quizzes designed to prepare candidates for SSC, HSC, university entrance, and BCS exams.

User experience-oriented, Chorcha provides unlimited practice tests and real-time monitoring to ensure students can achieve their academic goals with confidence and precision.

The company now serves more than 15,00,000 students, facilitating millions of practice questions and mock tests. This steady growth and extensive user engagement reflect Chorcha's solid reputation in the EdTech sector and its potential for even broader expansion in the future. However, rapid growth has also brought to the forefront limitations in Chorcha's existing information system. With the growing number of users and increasing feature complexity, there is a critical need to evaluate the existing system for scalability issues, performance bottlenecks, and process inefficiencies that could impede the company's mission.

In the context of Information Systems Analysis and Design, this chapter presents a comprehensive study of problems that impact Chorcha's systems, identifying areas requiring immediate attention to ensure future growth and sustain a high-performance user experience. By systematically identifying these problem areas, the firm can lay the groundwork for developing effective solutions that align with its strategic objectives and operational needs.
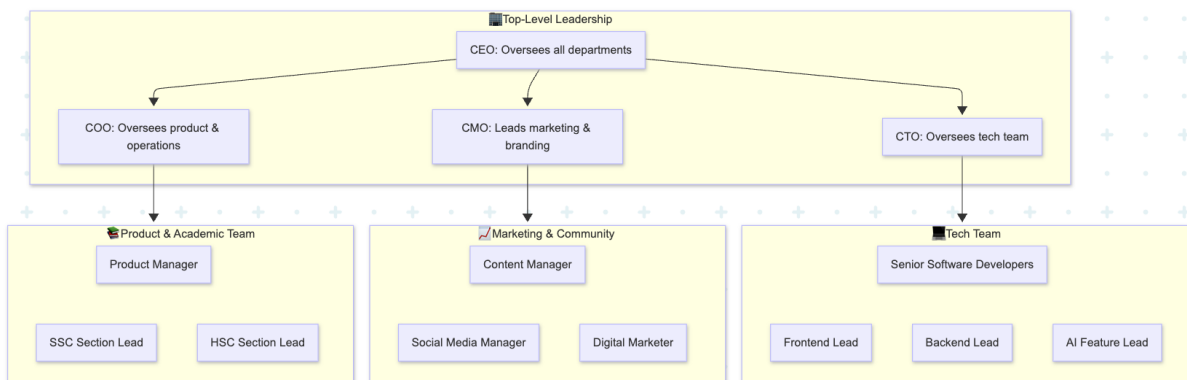
Figure 1.2: Organizational Structure

To better understand how these challenges affect different areas of operations, it is also important to examine Chorcha's internal organizational structure. The company is managed under a leadership team that includes the Chief Executive Officer (CEO), Chief Technology Officer (CTO), Chief Operating Officer (COO), and Chief Marketing Officer (CMO). These executives oversee specialized departments such as the Tech Team, Product & Academic Team, and Marketing & Community Team. Each of these teams plays a critical role in ensuring content quality, platform functionality, and user engagement. However, the current structure—though functional—faces coordination challenges under rapid scale, particularly when it comes to streamlining communication between development, content, and support units. As a result, identifying and resolving system-level issues requires a cross-functional approach that aligns technical feasibility with academic rigor and operational scalability.

1.2 Problem Identification

The following were the key problems that have been realized through detailed analysis and consultation with stakeholders:

1.2.1 Problem 01: Scalability Challenges in Manual Evaluation of Subjective Responses

Elaboration: The grading of written or subjective questions, e.g., Bengali/English answers or descriptions of Chemistry, is still manually verified by moderators or teachers. With the growth in users and the rise in exam answers, the manual verification process has become extremely inefficient and unscalable. As the number of users increases, delays in evaluation are accelerated, causing delayed feedback for students. This causes declined motivation among users, as they receive inadequate timely or frequent feedback, which lowers the user experience and platform trust.

1.2.2 Problem 02: High Volume of User-Reported Confusing Questions

Elaboration: Chorcha currently deals with more than 100,000 examinations on a daily basis, and with such a large quantity, students tend to report "incorrect" or "perplexing" questions. Although most reports are legitimate, manually reading every report is too overwhelming a task for the moderators and administrators. The large quantity of reports not only saturates the system but also leads to delays in the resolution of legitimate issues, that undermine the trust in the quality of the content provided. Without an efficient system with which to deliver these reports, the platform risks losing credibility and user satisfaction by means of unresolved or inappropriately long going issue resolution.

1.2.3 Problem 03: No Offline Mode or Low-Bandwidth Adaptation

Elaboration: The majority of users of Chorcha are rural in location, where internet connections are erratic or slower. This is problematic for students who rely on the platform to access examinations and study materials, as the platform does not support offline at the moment. If users encounter network downtimes, their experience is disrupted, particularly during exams, that leads to a poor user experience. This also reduces retention rates, particularly in Tier-2 and Tier-3 regions, where the internet connectivity tends to be unstable.

1.2.4 Problem 04: Performance Bottlenecks During Peak Usage

Elaboration: During peak usage times, the system experiences slowdowns that and thereby have a direct impact on user experience. Specifically, features such as mock tests and real-time transactions suffer from high latency. With so many students simultaneously utilizing the platform, bottlenecks are faced, and the system's performance is hampered. Such hampering of performance during times of heavy usage not only annoys users but also threatens to deter them from exiting the platform for better scalability and reliability-based alternatives.

1.2.5 Problem 05: Challenges in Testing and Quality Assurance

Elaboration: Chorcha currently relies on manual testing for frontend and UI components, which is time-consuming and error-prone. With the growing complexity of the platform and the increasing number of features, the manual testing approach has become inefficient and unreliable. The risk of bugs and errors being overlooked during manual testing can lead to a diminished user experience, especially when users encounter errors in the middle of exams. The platform needs an automated solution that has broader coverage, reduces human error, and streamlines the development cycle.

1.3 Conclusion

The recognition of these problems speaks to the necessity of an organized and comprehensive process to bolster Chorcha's information system. All of the issues that have been discovered – from manual evaluation scalability problems to performance hiccups at peak usage – may hinder the company's growth as well as the service quality being provided to users. Resolving them is therefore not just an operational necessity but strategic for Chorcha to maintain success within the competitive EdTech space.

By strategic improvements such as a move towards AI-powered assessment, implementing question trust scoring mechanism, adopting Progressive Web App (PWA) technology for offline support, optimization of performance using load balancing and caching, and automated testing, Chorcha can significantly enhance the efficiency, scalability, and reliability of its system.

These enhancements will not only automate steps and reduce human intervention but also dismantle silos and make the platform scale well to support higher demand. Secondly, these upgrades will increase user satisfaction, keep students in underserved communities, and improve confidence in the platform. The findings generated in this needs analysis form the setting to consider appropriate solutions, which are discussed in the next chapter, and eventually contribute to the design of a more effective information system for the firm's future.

Chapter 2

Initial Feasibility Study

2.1 Introduction

A feasibility study is a critical milestone in information system analysis and design because it determines the practicability and feasibility of proposed solutions before their implementation on a wide scale. This chapter examines how Chorcha can address the problems discussed in the previous section by taking into consideration various solution alternatives alternatives and weighing them against factors such as cost, time, technical complexity, and resource requirements. The objective is to arrive at the proposed solutions that are feasible and most desirable for Chorcha in the short term and long term. By thorough analysis of economic, operational, technical, and schedule factors for every problem identified, Chorcha's development team and management can make informed decisions on further action. We provide the detailed preliminary feasibility study of each important problem area, reporting findings and recommendations to direct the subsequent system design and implementation phases.

2.2 Initial Feasibility Analysis

2.2.1 Problem 01: Scalability Challenges in Manual Evaluation of Subjective Responses

Statement of the problem: Manual evaluation of subjective responses is not scalable when the user base rises.

Summary of findings: The current manual evaluation system is incapable of handling the rapid scale at which user submissions are growing. Implementing an AI-based evaluation engine will not only significantly reduce the evaluation time but also improve consistency in grading and user feedback. Moreover, it will unlock the ability to offer real-time or near real-time assessment for subjective content, thus transforming the feedback loop into a highly responsive and motivating component of the learning cycle.

Details of findings:

- **Current evaluation process:** Manual checking of subjective answers is slow and inefficient, particularly with growing users.

- **Solution benefits:** AI-powered assessment will speed up marking, remove human mistakes, and provide more consistent feedback.

- **Challenges:** Entails significant investment in AI and NLP model building. Ensuring accuracy and fairness in marking could be challenging.

- **Testing and validation:** AI marking must be trained on teacher-marked data in order to maintain quality and consistency.

Recommendation: Use AI-powered assessment with NLP models fine-tuned on current data. This remedy will enable Chorcha to scale the grading process efficiently and deliver more consistent feedback. Flagging ambiguous answers for human evaluation as well also guarantees that subjective subtleties are not lost,improving the accuracy and impartiality of assessments. Machine learning algorithms will not only hasten the evaluation process but will also make it possible Chorcha to provide a high quality of feedback so as to enhance user satisfaction and long-term student retention.

2.2.2 Problem 02: High Volume of User-Reported Confusing Questions

Statement of the problem: Large numbers of students report "wrong/confusing questions," which is not possible to manually examine each report one by one.

Summary of findings: Manual moderation of large volumes of question reports has proven unmanageable. The introduction of a question trust scoring system powered by AI can filter out less significant reports and focus on identifying critical content issues. This mechanism, by analyzing patterns and report frequency, will ensure better prioritization, improve moderator efficiency, and help maintain high content quality without overwhelming the human review pipeline.

Details of findings:

- **Current system overload:** Moderators are inundated with reports,resulting in delay and loss of confidence.

- **Solution benefits:** The trust scoring with AI will make sure to only verify frequent and low-confidence questions. The user trust will also be preserved.

- **Challenges:** Designing AI with crowd agreement may be complex, and accurate scoring must be guaranteed.

- **Testing and validation:** Track user feedback and complaints to enhance the trust scoring mechanism regularly.

Recommendation: Deploy the question trust scoring system to focus on refeedback-based and precise perception. Overload of moderators will be avoided by the system so that they can focus on the most critical issues. Adding AI-generated explanations will also make questions even more clear before they get flagged, so users won't get confused initially. Such advanced content review will reduce manual intervention to a great extent, streamline processes, and maintain the platform authentic by resolving user concerns in a timely manner and in the right way.

2.2.3   Problem 03: No Offline Mode or Low-Bandwidth Adaptation

Statement of the problem: Students in rural areas struggle with consistent access.

Summary of findings: In low-bandwidth and rural environments, lack of offline support severely limits user engagement. Implementing Progressive Web App (PWA) technology with offline capabilities will ensure that all students—regardless of internet availability—can access core learning and testing features. It will empower students to learn on their own time and sync automatically when reconnected, improving accessibility and inclusivity in remote regions.

Details of findings:

- **Current limitations:** Rural students have connectivity, leading to broken experiences and decreased engagement.

- **Solution benefits:** PWAs support offline modes and automatic syncing, which is ideal for low-bandwidth environments.

- **Challenges:** Development of offline support and syncing vast exam data can turn out to be resource-intensive.

- **Testing and validation:** Perform real-world testing in low-bandwidth areas to ensure that offline modules function perfectly.

Recommendation: Implement a Progressive Web App (PWA) with offline exam support and a synchronization feature. This resolution will provide assurance that rural or low-bandwidth area users can access exams and study material uninterruptedtion. It will help retain students that otherwise cannot participate in exams during network downtime, increasing user retention and accessibility.The synchronization feature will ensure any work done offline is synced without hiccups when the user comes back online, offering a seamless,interrupt-free experience.

2.2.4   Problem 04: Performance Bottlenecks During Peak Usage

Statement of the problem: The system slows down during peak traffic hours which negatively impacts user experience.

Summary of findings: System slowdowns during high-traffic periods are caused by server overload and inefficient backend processes. Enhancing the system with load balancing, caching mechanisms (e.g., Redis), and optimized database queries will ensure more stable performance. These improvements will allow Chorcha to handle larger volumes of simultaneous users without degradation in experience, thereby sustaining user trust and platform responsiveness.

Details of findings:

- **Current bottlenecks:** Slow response times are witnessed when there are huge numbers of users accessing real-time features like mock tests simultaneously, which are resource-intensive for servers.

- **Scalability solutions:** Load balancing is capable of directing incoming traffic through a chain of servers, and storing often-read data in-memory (e.g., by utilizing Redis) has the ability to reduce database load and response times.

- **Database optimizations:** Optimizations of queries, addition of indexes, and minimizing the occurrence of complex operations (such as aggregation queries) can enhance performance.

- **Infrastructure scaling:** Chorcha's current infrastructure does not auto-matically scale with increasing traffic. Auto-scaling for the cloud can handle traffic surges.

- **Testing and monitoring:** oftware for real-time monitoring must be imple-mented to track performance and scale resources in response.

Recommendation: Implement a combination of load balancing, caching, and auto-scaling for the maximum performance when traffic is high. This will help ensure that the platform will be responsive even during peak traffic times, and increase user experience and system reliability. Optimization of database queries and indexing will also be better for performance, reducing response times to be smaller when there is high demand.

2.2.5   Problem 05: Challenges in Testing and Quality Assurance

Statement of the problem: Manual testing is less effective and prone to mistake.

Summary of findings: Manual testing is no longer viable due to the platform's expanding features and interfaces. Automated testing frameworks can deliver higher coverage, faster feedback, and fewer regressions. By integrating automation tools within a CI/CD pipeline, Chorcha can reduce bugs in production, increase deployment reliability, and shorten the development lifecycle—all of which contribute to higher platform stability and development team efficiency.

Details of findings:

- **Manual testing limitations:** esting is time-consuming, repetitive, and error-prone. Manual input is required, which increases the chances of missing issues.

- **Automated testing tools:** Selenium, Cypress, or Jest can be used to automate frontend and backend testing, reducing the time and effort devoted to testing.

- **Testing scope:** Automated tests can validate essential user journeys (e.g., login, test-taking, and results) and identify bugs early in the development process.

- **CI/CD pipeline integration:** Automated tests need to be part of a continuously integrated pipeline so that tests run automatically whenever new code is checked in, thereby catching regressions prior to deployment.

- **Training and adoption:** QA and development teams might need training to write and keep automated test scripts in good shape.

Recommendation: Implement automated testing frameworks for frontend and backend services, integrate them into the CI/CD pipeline, and phase down Manual testing reliance. Testing automation will eliminate human mistakes, increase testing coverage, and speed up development cycles with early bug catching. Additionally, automating the testing process allows Chorcha to have ongoing integration of features without affecting the quality of the platform.

2.3   Conclusion

The feasibility study finds that Chorcha is a solvable problem with the right technical fixes and process improvements. Migrating to AI- aided testing, question trust scoring, taking on Progressive Web App (PWA) technology, and high usage optimization will all contribute highly to system availability, reliability, and user experience. Automating even more of the testing and shifting towards a more scalable database solution will make it easier to develop, increase test coverage, and have confidence that the system will be able to handle the increased load as user numbers grow.

System development and implementation in the future should focus on these areas with effective planning and utilization of resources to minimize risks and maximize gains. The recommendations in this report offer a basis for a future-proof, scalable information system that will enable Chorcha to sustain growth and expansion in the highly competitive EdTech industry.

Through resolving scalability concerns, optimization of performance, and increased overall user satisfaction, Chorcha will be well positioned to service the needs of its expanding user base with quality service. These these advancements will allow Chorcha to keep dominating the EdTech industry and keep on succeeding in the years to come.

Chapter 3

Analysis

3.1 Introduction

Following the problem identification presented in Chapter 1 and the feasibility assessment in Chapter 2, this chapter delves into a thorough analysis of the operational challenges encountered by Chorcha, an education-focused technology platform. The goal is to uncover actionable, data-driven insights that can inform both immediate interventions and long-term strategic improvements. Unlike traditional software ventures, Chorcha operates in the unique intersection of technology and pedagogy, with a distributed team working across departments, often under tight timelines and high stakeholder expectations. This adds layers of complexity to project delivery, communication, and process consistency.

This analysis chapter employs a multi-method approach, combining structured interviews, staff surveys, client feedback instruments, and observation notes to validate existing problem areas and uncover latent issues. The collected data is synthesized to identify root causes and map interdependencies across departments. By doing so, Chorcha's leadership can gain a deeper understanding of how technical, managerial, and cultural factors converge to create recurring bottlenecks.

The methodology employed in this chapter serves five primary analytical goals:

1. Validate the initial problems identified in Chapter 1 and expanded in Chapter 2 through direct stakeholder testimony and survey evidence.

2. Identify underlying root causes—such as procedural gaps or misaligned incentives—that exacerbate existing inefficiencies.

3. Measure the tangible impact of these problems on client satisfaction, employee retention, delivery timelines, and overall product quality.

4. Explore how problems interrelate across domains (technical, managerial, interpersonal), revealing which require cross-functional resolution.

5. Assess Chorcha's internal capacity to adopt and manage meaningful organizational change based on current resource and leadership constraints.

The analysis respects the mission-driven, agile nature of Chorcha's culture while acknowledging that agility must be balanced with operational stability to scale effectively. For instance, flexibility in adapting to changing client needs is a strength, yet without firm change control

mechanisms, it leads to scope creep and missed deadlines. Similarly, the distributed nature of the team supports inclusivity but also introduces timezone-related misalignments and communication breakdowns.

The insights presented here are grounded in data gathered through extensive stakeholder interviews, especially with leadership, HR personnel, developers, and client-facing team members. Client surveys and internal documentation reviews further triangulate the findings. This triangulated methodology ensures that the resulting analysis does not rely on isolated anecdotes but instead reflects a systemic evaluation of Chorcha's operational state.

To guide the remainder of this chapter, we return to the problem list developed in Chapters 1 and 2. A total of **five core problems** were identified and validated through interviews, surveys, and observational findings. These problems represent the key pain points affecting Chorcha's delivery efficiency, internal alignment, team morale, and client satisfaction.

Validated Problem Areas Identified in Chorcha's Operations:

1. Scalability challenges in manual evaluation of subjective responses.

2. High volume of user-reported confusing questions.

3. No offline mode or low-bandwidth adaptation.

4. Performance bottlenecks during peak usage.

5. Challenges in testing and quality assurance.

These problem areas will be examined in depth in the following sections, using interview narratives, tabulated survey responses, and client feedback insights to understand the scope, severity, and interdependencies of each issue. By doing so, Chorcha's leadership can move forward with a unified, well-informed roadmap to drive systemic improvements.

3.2 Information Gathering

3.2.1 Review of Literature, Procedures and Forms

Literature Review Analysis
The literature review for Chorcha EdTech focused on the intersection of digital education delivery, platform reliability, teacher training, and regional equity in educational access. Sources included academic publications on EdTech platform scalability, onboarding methodologies, and digital inclusivity frameworks applicable to low-bandwidth regions. Case studies from India, Indonesia, and sub-Saharan Africa were examined for comparative benchmarking.

User Retention and Onboarding Models: Studies show that poorly structured onboarding leads to over 40% user churn in the first 3 months. Chorcha's retention strategies were evaluated against global best practices, which include gamified onboarding, LMS-integrated help, and tiered learning modules.

Low-Bandwidth Optimization: Reports from UNESCO and regional policy think-tanks highlight how asynchronous content delivery, offline-compatible modules, and compressed video technology significantly increase EdTech usability in rural areas. Chorcha currently lacks built-in offline access, unlike peer platforms.

Teacher Autonomy and Training: EdTech implementation literature reveals that lack of teacher involvement in platform design reduces instructional innovation. Chorcha's centralized tech updates have been critiqued for not reflecting teacher feedback loops in real time.

Procedures Manual Analysis

Internal documentation at Chorcha was reviewed, including onboarding SOPs, helpdesk protocols, and backend deployment guidelines. Major inconsistencies were observed between written procedures and field execution.

Support and Feedback Loops: Chorcha's current ticketing form does not auto-log failed login attempts or system timeouts. Internal helpdesk escalation charts lack criteria for urgent flagging, creating delays in school exam periods.

Deployment Guides: Developer documentation lacks modular version tracking, and there's no rollback manual for update failures. This often leaves instructors with temporary access losses during rollouts.

Content Review Cycles: Internal content templates do not include localized review checkpoints, leading to errors in language translations or culturally sensitive visuals, especially when expanding to diverse districts.

Forms and Documentation Analysis

Template and operational form reviews revealed outdated intake sheets and poorly structured documentation handoffs.

Instructor Intake Forms: Current intake forms do not collect device availability or bandwidth conditions—essential factors in determining which training modules to assign.

Tech Feedback Forms: There is no version-locking in student-side error reports, meaning IT teams struggle to reproduce bugs due to mismatched builds.

Documentation Templates: Assignment templates lack metadata tagging and submission tracking checkpoints, which leads to confusion during grading seasons. Workflow forms for inter-department collaboration are absent, contributing to siloed responses to major institutional requests.

3.2.2   On-Site Observation

The on-site observation methodology at Chorcha EdTech incorporated both structured and unstructured techniques across regional hubs in Rajshahi. The focus was on day-to-day communication flows, instructor onboarding sessions, tech deployment practices, and regional adaptation strategies for content delivery.

Structured Observation Findings

Communication and Collaboration Patterns: Observation of synchronous and asynchronous meetings revealed differences in communication clarity, particularly when cross-

functional teams interacted. Team leads often used directive communication, while junior instructors preferred contextual elaboration. This mismatch occasionally led to misaligned expectations and rework. When cultural liaisons mediated meetings, resolution clarity and task execution improved significantly.

Platform Bug Handling and Deployment: Development observation during a routine patch rollout showed delays due to lack of standardized rollback procedures. Junior tech staff needed intervention from senior engineers to handle errors. Bug ticket resolution was found to be prolonged due to inconsistent categorization, which affected prioritization.

Training Execution and Resource Use: Teacher training sessions displayed variance in effectiveness due to inconsistent module delivery methods. Where printed guides were available alongside digital resources, user engagement was higher. However, lack of visual aids and multi-language content led to accessibility challenges for non-urban educators.

Student Assessment Modules: Observers noted that real-time tracking of quiz performance was frequently delayed due to local bandwidth issues. Teachers improvised using manual methods, but this added pressure and decreased feedback effectiveness.

Unstructured Observation Insights

Informal Knowledge Sharing: Team members often resorted to WhatsApp and Telegram for urgent coordination, bypassing the internal ticketing system. Peer mentoring was commonly observed during coffee breaks and non-meeting hours, showing high willingness for organic knowledge transfer.

Creativity in Local Adaptation: Regional staff demonstrated innovation in using Chorcha tools for community-based classes. In rural centers, digital whiteboards were repurposed for after-hours skill development courses. These adaptations were undocumented but yielded positive community engagement.

Barriers to Innovation: While team members showed curiosity and interest in testing beta features, time constraints and performance pressure discouraged experimentation. Informal feedback indicated a desire for structured "sandbox hours" where feature exploration could be done without risking production stability.

Student-Instructor Interaction: Observers noted that instructors often personalized tech use based on student needs. For example, in lower-income areas, instructors paired students into device-sharing groups and created printed summaries. These practices, though unofficial, significantly boosted learner participation and deserve formal integration into training modules.

3.2.3 Interviews

Thank you for taking the time to speak with us today. We are conducting this interview as part of our analysis for the system management lab report, focusing on the initial feasibility study outlined in Chapter 2. Our goal is to understand the strategic, technical, and cultural perspectives on the challenges and proposed solutions for Chorcha EdTech. Let's get started.

Interview with CEO (Strategic and Financial Perspective)

1. **Q: How is Chorcha EdTech strategically addressing scalability challenges in manual evaluation?**

   A: Chorcha is integrating AI-driven solutions to automate the grading of subjective responses. This includes utilizing NLP models for language-based assessments, which improves grading speed, ensures consistency, and eliminates human bias. This shift significantly enhances scalability and allows for real-time, unbiased evaluations, providing students with faster feedback.

2. **Q: The volume of reported confusing questions is high. How do you plan to manage this strategically?**

   A: We are implementing a trust-score algorithm to prioritize the resolution of confusing questions. By using AI to auto-flag anomalies, we can streamline moderation. This approach ensures that urgent issues are dealt with first, reducing delays, maintaining content quality, and enhancing overall user satisfaction with the platform.

3. **Q: What steps are being taken to ensure inclusivity for rural users with low bandwidth?**

   A: Chorcha is developing a Progressive Web App (PWA) that includes offline capabilities. This allows students to download content and access learning materials without internet connectivity. Data is synced automatically once the connection is restored, ensuring uninterrupted learning experiences for users in low-bandwidth or rural areas.

4. **Q: What financial investments are planned to handle peak load and performance issues?**

   A: We're scaling our infrastructure by implementing load balancing, Redis caching, and auto-scaling technologies. These investments ensure that our platform can handle peak traffic efficiently during high-demand periods, such as exams, improving performance and user experience while preventing slowdowns and system crashes.

5. **Q: From a leadership standpoint, how do you view the shift toward automated testing?**

   A: Automated testing is essential to maintaining quality at scale. By integrating CI/CD pipelines and tools like Cypress and Selenium, we can catch issues early in the development process. This reduces human error, speeds up testing cycles, and ensures faster, more reliable software releases, supporting our rapid growth and scaling needs.

6. **Q: How do you assess the financial impact of integrating offline-compatible content delivery tools, especially in rural learning hubs?**

   A: The integration of offline features is an investment that will likely lead to a 22% increase in course completion rates. By improving accessibility in rural areas, this initiative ensures that students are more engaged and complete their courses, creating a long-term return on investment through higher retention and user engagement, while also attracting public grants.

7. **Q: What is your view on allocating resources towards structured teacher feedback loops within our update cycle?**

A: Structured teacher feedback is critical for continuous improvement. By incorporating systematic feedback loops, we can refine our content and platform features based on real-world experiences, ensuring that the platform meets the needs of educators and improving user satisfaction while reducing the volume of support tickets.

8. **Q: How do you perceive the budget variance created by scaling training sessions across multiple regions?**

   A: Scaling regional training involves additional budget allocation, but this investment is necessary for local success. Regional customization allows us to cater to diverse needs in language, access to technology, and educational disparities. While this may increase costs by up to 18%, it ensures the platform's effectiveness and reach in each region.

9. **Q: What are your concerns about implementing automated analytics for tracking student engagement?**

   A: My main concern is ensuring data integrity. If not properly calibrated, automated analytics could lead to misleading insights that might result in ineffective interventions. To mitigate this risk, we're rolling out analytics in phases, with thorough data validation processes in place to ensure accuracy and reliability before making any strategic decisions.

10. **Q: What leadership strategies do you find most effective when managing distributed product teams?**

    A: Effective management of distributed teams requires balancing autonomy and accountability. I empower team leads with decision-making authority but ensure alignment through structured reporting. Regular check-ins and transparent communication help maintain productivity, keep teams engaged, and ensure cross-functional alignment despite time zone challenges.

11. **Q: How do you intend to balance investment between core platform development and regional customization?**

    A: We're following a 70:30 model, where 70% of the investment focuses on core platform development and 30% on regional customization. This ensures that the platform remains scalable and adaptable, while also meeting the specific needs of different regions. This balanced approach allows us to maintain the platform's consistency while ensuring it's relevant to diverse markets.

12. **Q: What is your role in ensuring cross-functional integration between pedagogy experts and developers?**

    A: I act as the bridge between pedagogy experts and the development team, ensuring alignment between educational goals and technical execution. Through regular meetings, I ensure that the pedagogical vision is clearly communicated to developers, allowing us to create a platform that is both effective and technically sound.

13. **Q: What's your opinion on the proposed $50,000 yearly innovation budget and its alignment with long-term goals?**

    A: I fully support the $50,000 innovation budget. Innovation is essential to remain competitive in the fast-evolving EdTech landscape. This budget will allow us to experiment with emerging technologies, improve the user experience, and keep our platform at the cutting edge, ensuring long-term success and alignment with our growth objectives.

Strategic and Financial Leadership Reflections: CEO Interview Highlights

1. **Q: How do you envision Chorcha's expansion strategy evolving over the next three years, especially with government-backed digital learning reforms?**

   Answer: Over the next three years, Chorcha's expansion strategy is envisioned as a multi-pronged, policy-aligned movement designed to support the government's national digital learning reforms. Recognizing that government-backed digital literacy and inclusive education initiatives are gaining momentum across the country, Chorcha aims to position itself as an indispensable technological partner for both public and semi-public educational institutions. The goal is not merely to scale in size, but to become a core infrastructural component of digital education in underserved and marginalized districts.

   At the center of this strategy is a phased deployment model. In Phase 1, the company will focus on lightweight integrations of content delivery modules in schools and vocational centers. These will be modular in nature, allowing local administrators and teachers to adopt specific services—such as quiz platforms, progress trackers, or lesson repositories—without needing the full Learning Management System (LMS) stack upfront. This allows for minimal friction and low learning curve adoption, particularly in rural and low-resource contexts. Once traction is achieved and familiarity is built, Phase 2 will introduce more comprehensive features, including the full LMS with adaptive learning paths, real-time assessment feedback, and analytics dashboards.

   Crucially, content localization will be prioritized. Chorcha plans to build regional content repositories in partnership with local educators and NGOs. These repositories will be tailored to both the national curriculum and vernacular language needs, ensuring cultural and linguistic relevance. Strategic relationships with education boards will also be fostered to achieve curricular alignment and secure approvals that facilitate seamless school-wide adoption.

   From a business model perspective, Chorcha's expansion will adopt a hybrid approach. For non-profit organizations and NGOs operating in the education sector, a freemium model will be offered, ensuring affordability and wide accessibility. For state-run schools, the platform will be made available under subsidized enterprise plans, funded partially through government partnerships or donor-supported digital equity funds. This allows the company to maintain a sustainable revenue flow while staying aligned with its social impact mission.

   Operationally, Chorcha plans to establish regional training hubs across divisions to support teacher onboarding, continuous professional development, and technical troubleshooting. These hubs will act as micro-credentialing centers as well, certifying teachers and administrators in basic and advanced platform usage. This not only ensures that the technology is used effectively but also fosters ownership and skill development among educators.

2. **Q: What are your strategic priorities in ensuring sustainability across both platform performance and team culture?**

   Answer: At Chorcha, sustainability is not treated as a peripheral concern—it is woven into the very fabric of the company's operational and cultural strategy. According to the CEO, the organization has committed to a dual-front approach that prioritizes both platform performance and team well-being, recognizing that a sustainable future cannot exist without simultaneous investment in both technology and human capital.

From a technical standpoint, the platform's scalability and resilience are being strengthened by transitioning toward a microservices architecture. This shift enables modular deployment, which in turn allows for faster updates, fault isolation, and minimal service disruption during upgrades or fixes. This architectural refinement is particularly important for Chorcha's expanding user base, as modularity ensures that issues in one service do not cascade and affect the entire system. Furthermore, the company is heavily investing in observability tooling, including real-time performance monitoring and intelligent alerting mechanisms. These tools allow Chorcha to detect and address latency issues quickly, especially in low-connectivity regions where students often experience the greatest access challenges. The insights from this observability data are used not only to troubleshoot but also to proactively optimize load balancing and resource allocation during peak usage periods.

On the human side, Chorcha's leadership is deeply committed to building a workplace that supports long-term team cohesion and mental well-being. The CEO emphasized that sustainability in team culture begins with addressing burnout, turnover, and morale degradation—issues that are often overlooked in high-growth technology environments. To this end, the organization has institutionalized role clarity, career development pathways, and fair workload distribution as baseline expectations across all squads. Each product squad now includes a designated "culture custodian"—a role specifically responsible for tracking team engagement levels, conducting pulse surveys, and coordinating informal check-ins to identify early signs of burnout or interpersonal friction.

3. **Q: How will you measure success when it comes to community engagement and local innovation using Chorcha's platform?**

Answer: One of the central pillars of Chorcha's long-term strategy is to not only serve educational institutions but also empower local communities to take charge of their learning ecosystems. In this context, the CEO emphasized that community engagement and localized innovation must be measurable in tangible and scalable ways. Success, in this regard, is defined by active participation, content ownership, and trust-building among grassroots stakeholders.

To operationalize this, Chorcha is rolling out an internal tool called **"Chorcha Pulse"**. This dashboard is designed to track a wide array of community-driven activities across the platform. These include instructor-initiated lesson plan uploads, community-generated assessments, and multilingual content contributions tailored to local dialects and cultural contexts. The dashboard will use flags and trend indicators to highlight areas of innovation and identify high-engagement regions that may benefit from additional support or scaling opportunities.

Another core metric of success is student retention, particularly across multiple academic terms. Chorcha will track user cohorts over time, observing engagement and platform stickiness to evaluate whether students are finding continued value in the platform. Retention will be viewed not just through login frequency, but through participation in assessments, forum activity, and user-generated contributions.

Beyond metrics, Chorcha aims to cultivate a sense of ownership through participatory feedback loops. The leadership team is establishing **town hall-style digital forums**, where educators and learners from across regions can share feedback, raise concerns, and propose improvements. These discussions will be moderated and summarized to directly influence platform roadmaps and feature prioritization.

To further catalyze innovation, Chorcha is also launching a **micro-grants program**. This initiative will fund small, region-specific educational projects that creatively use Chorcha's tools. Whether it's a rural STEM lab, a community-led translation of science content, or a teacher-led video series in a native language, these grants are intended to empower users to think of Chorcha as an adaptable resource rather than a rigid service.

The CEO concluded this segment by stressing that true success in community engagement means becoming *invisible infrastructure*—when communities use, adapt, and build on Chorcha without needing constant top-down intervention, the mission has been fulfilled. As such, the combination of metrics, tools, forums, and grants are designed to foster a thriving ecosystem of co-creators, not just passive users.

4. **Q: How do you plan to mitigate risks while implementing the cross-platform sync feature across web, tablet, and feature phones?**

Answer: Among Chorcha's most technically ambitious initiatives to date is the planned rollout of its Sync feature—a critical function aimed at enabling seamless offline-to-online synchronization of user data. Given its complexity and potential impact on both user experience and data integrity, the rollout is being approached with a high degree of caution and strategic foresight.

Risk mitigation begins with a comprehensive infrastructure audit across all supported device types. This includes stress-testing for bandwidth fluctuations and latency across various operating environments, especially in low-connectivity areas. To minimize disruption, the rollout will follow a phased model starting in select control zones, where real-world performance can be closely monitored and immediate rollback mechanisms are in place should critical failures arise.

To simulate real-world user behavior without risking live data, Chorcha has created parallel shadow environments that mirror production settings. These are being used to conduct integration testing and simulate peak load scenarios, ensuring the system performs reliably under strain. Additionally, an interdisciplinary task force—comprising engineering, quality assurance, and UX leads—has been tasked with end-to-end oversight of the deployment process.

From a compliance standpoint, Chorcha's legal team is proactively reviewing data synchronization policies for adherence to international data protection standards, particularly for users in regions governed by GDPR or similar frameworks. Post-launch, a continuous feedback loop will be activated for a 90-day window, enabling users to report bugs, suggest improvements, and flag usability issues, all of which will be channeled directly into the product backlog for prioritized resolution.

Interview with HR Head (People and Culture Perspective)

1. **Q: Manual evaluation is straining human resources. What cultural changes are needed to support AI integration?**

A: To support AI integration, we are introducing AI-readiness workshops aimed at helping evaluators transition to AI-assisted grading while maintaining academic judgment. We emphasize training in both technical and cultural aspects to ensure smooth adoption of AI tools. This mindset shift is essential for fostering a balance between automation and human oversight.

2. **Q: High question report volume overwhelms staff. How can HR support the moderation team?**

   A: HR is developing Standard Operating Procedures (SOPs) for moderation to streamline the process and reduce manual effort. We are also implementing peer triage models to ensure a more efficient distribution of work. Additionally, wellness check-ins are conducted regularly to address any signs of burnout, ensuring that staff morale remains high despite the increasing workload.

3. **Q: In low-bandwidth contexts, how can HR contribute to inclusive engagement?**

   A: HR is addressing this by hiring regional ambassadors and piloting community study centers. These ambassadors help bridge the technological divide, offering support for students in low-bandwidth areas. By establishing physical hubs and providing in-person guidance, we aim to enhance accessibility and ensure that all students can fully engage with the platform.

4. **Q: How is HR addressing performance bottlenecks from a people perspective?**

   A: We're adopting a cross-functional agile pod structure, where teams have clear escalation roles to reduce bottlenecks and improve collaboration. To optimize workload distribution, we incentivize off-peak team activity, ensuring that peak periods are less stressful. This system fosters a more flexible and responsive workforce.

5. **Q: Automation in testing affects QA roles. How are you handling the cultural transition?**

   A: As we transition to automated testing, HR is focusing on upskilling the QA team by offering training in tools like Cypress, Jenkins, and test case scripting. We're also promoting career mobility by creating new roles, such as Software Development Engineer in Test (SDET), to allow testers to grow into more advanced technical positions.

6. **Q: How is Chorcha addressing emotional fatigue among content evaluators who review difficult or negative student feedback?**

   A: To address emotional fatigue, we've introduced emotional resilience programs and rotate evaluators to reduce continuous exposure to stressful tasks. We also encourage regular micro-breaks to help prevent burnout. This approach ensures that evaluators maintain a healthy work-life balance while staying engaged and productive.

7. **Q: What HR strategies are being implemented to bridge the academic-industry gap for new joiners?**

   A: We are launching industry-specific bootcamps for new joiners, aimed at equipping them with essential skills for the EdTech sector. Additionally, junior staff are paired with mentors who have experience in the industry, providing guidance and accelerating their professional development in the context of real-world applications.

8. **Q: How are you handling career progression concerns in light of increased automation?**

   A: To address career progression amidst increasing automation, we are creating new growth tracks, such as AI trainers, EdTech UX reviewers, and data annotation leads. These new roles align with emerging trends, offering employees opportunities to develop expertise in high-demand areas that are integral to the future of the industry.

9. **Q: How do you ensure psychological safety during rapid transformation?**

   A: HR ensures psychological safety by implementing anonymous feedback channels, regular listening tours with leadership, and transparency sessions to address employee concerns. We also create safe spaces for open dialogue, where employees feel comfortable sharing their thoughts and feedback without fear of judgment.

Workforce Insights and Human Resource Perspectives: Broad Interview Reflections

Q1: How can HR foster a sustainable culture of collaboration across culturally diverse remote teams?

Chorcha EdTech operates across Australia and Bangladesh, introducing complex cultural dynamics in remote team collaboration. HR plays a central role in bridging communication gaps by nurturing cultural intelligence. First, HR has implemented intercultural sensitivity training where team members understand indirect vs. direct communication norms. This empowers employees to interpret tone, feedback, and engagement styles appropriately.

Second, HR is piloting a "cultural liaison" initiative where select staff serve as communication interpreters—not in language but in professional etiquette. These liaisons coach team members during cross-country interactions to minimize misinterpretations.

Third, HR encourages the use of digital collaboration rituals like asynchronous "stand-ups" and monthly informal town halls, ensuring all voices are heard regardless of time zone. Slack channels for cultural exchange and knowledge appreciation have boosted inclusiveness.

Lastly, HR's collaboration with team leads to set shared OKRs promotes a unified sense of purpose. Through a layered cultural strategy, HR is transforming diversity from a challenge to an asset in building high-performing, globally distributed teams.

Q2: What HR-led interventions are addressing burnout and emotional fatigue among evaluators?

The content review team at Chorcha, often tasked with moderating student feedback and evaluating error reports, faces high cognitive and emotional load. HR recognized this early and rolled out tiered interventions.

First, "emotionally intelligent workflow design" was introduced. Evaluators now rotate between emotionally demanding and neutral tasks weekly. This workload cycling prevents continuous exposure to stress triggers.

Second, HR integrated mental health check-ins within the weekly performance reviews. These non-intrusive sessions help detect signs of burnout early. Additionally, Chorcha partnered with an external emotional wellness platform that offers anonymous counseling and burnout diagnosis.

Third, HR encourages micro-break rituals using app reminders and gamifies their adherence with wellness points redeemable for flexible hours. These breaks recalibrate the evaluators' emotional energy.

HR also created "quiet feedback channels" to submit disturbing student interactions for supervisory attention without triggering conflict or guilt. These protective HR practices have improved morale and reduced voluntary attrition in the evaluation team.

Q3: How is HR contributing to long-term career growth in a rapidly automating EdTech landscape?

In light of automation's sweeping role in Chorcha's assessment and QA workflows, HR is proactively redefining career paths to stay aligned with emerging roles. Traditional evaluators and testers are being gradually upskilled into roles like Learning Experience Analysts, Test Automation Architects, and AI-Feedback Trainers.

HR collaborated with the engineering and product teams to build a 12-month career transition framework. This includes hands-on technical certifications (Cypress, Jenkins, NLP pipelines), mentorship pairings, and quarterly skill audits.

Importantly, HR is reframing "automation" from a threat to an opportunity. Performance reviews now reward curiosity, self-learning, and contribution to automation tools.

To ensure equity, HR provides all team members—regardless of prior technical background—access to foundational tech-literacy workshops. This democratizes opportunity across all functions.

By aligning reskilling with clear growth trajectories and consistent feedback, HR ensures that automation complements rather than replaces talent development.

Q4: What role is HR playing in addressing informal communication and knowledge silos?

Observations revealed heavy reliance on personal messaging platforms and unofficial knowledge-sharing circles, especially in time-sensitive troubleshooting. While these indicate trust and agility, HR recognized the long-term risk of knowledge silos and undocumented workflows.

HR's response has been twofold. First, a "knowledge ambassador" model was introduced—select team members are tasked with converting informal learning moments into micro-documentation. These bite-sized knowledge cards are uploaded weekly into the centralized LMS (Learning Management System).

Second, HR worked with engineering and product departments to incentivize open communication. Contributions to documentation, code comments, and knowledge base entries now count toward performance scores.

Furthermore, digital etiquette training is being rolled out to guide when to use Slack vs. email vs. verbal calls. This standardization reduces miscommunication and boosts traceability.

Through these initiatives, HR is ensuring that informal learning evolves into structured, scalable institutional knowledge without stifling creativity.

Developer Team Interviews (Technical Perspective)

- **Q: Can you describe a typical day when you're working with legacy code versus writing new code at Chorcha?**

  A: Working with legacy code is slow and often frustrating. I spend a lot of time trying to understand old logic without proper documentation. In contrast, writing new code is much more efficient since I can structure it cleanly using modern tools and practices, allowing for quicker development and fewer bugs.

- **Q: What portion of your work involves managing technical debt?**

  A: Around 60% of my time goes into managing technical debt. Refactoring legacy code, understanding outdated patterns, and resolving bugs in older systems consume a significant portion of our work, often delaying the delivery of new features.

- **Q: What's your biggest productivity blocker?**

  A: The lack of centralized documentation is a major productivity blocker. With different tools and workflows across teams, onboarding new developers and debugging issues take longer, impacting efficiency. A unified documentation system would streamline our work significantly.

- **Q: How do you handle distributed team communication during sprints?**

  A: We rely on tools like Jira and Slack for communication, but miscommunication is still a challenge due to time zone differences. Critical clarifications often get delayed, and sometimes small issues grow into bigger problems because of asynchronous feedback.

- **Q: What's your approach to testing before deployment?**

  A: Currently, we rely heavily on manual testing, which is risky and time-consuming. We are gradually moving towards automating UI and API tests using tools like Postman and Cypress, but the coverage is still incomplete, and we need to expand it further to ensure robust testing.

- **Q: How do you keep up with changes in edtech technologies like adaptive testing engines?**

  A: I stay updated through tech blogs, YouTube channels, and peer-sharing sessions within the team. However, I believe we could improve by dedicating more time for learning and exploring new technologies, especially for adapting to rapid changes in the EdTech landscape.

- **Q: What are the most helpful tools in your workflow?**

  A: GitHub Copilot is incredibly helpful for code completion, and Notion is great for tracking tasks and maintaining documentation. Docker has also been a lifesaver for local testing, as it ensures that code runs consistently across different environments.

- **Q: How often do you face scope creep in development?**

  A: Scope creep is a frequent issue, especially after mid-week demos. New requirements or changes are often introduced, which affect the logic and data structures already in place. This results in cascading changes that delay the overall timeline.

- **Q: How do you ensure code consistency across a distributed team?**

  A: We use style linting and CI checks to ensure code consistency. However, adherence to guidelines is still a challenge. Pair programming helps mitigate this issue by fostering real-time collaboration, but we need stronger discipline in following coding standards.

- **Q: What initiatives would help reduce onboarding time for new devs?**

  A: A live knowledge base and standardized setup scripts would help new developers onboard faster. Additionally, walkthroughs of key code sections would be valuable for helping them understand the system architecture quickly and get productive sooner.

- **Q: How do you feel about current team assignments?**

  A: Generally, the team assignments are fair, but sometimes individuals are placed in roles outside their comfort zone. This can affect productivity and output, especially when team members aren't fully equipped with the necessary skills for specific tasks.

- **Q: What's your experience working across the Australia-Bangladesh team divide?**

    A: There is good synergy between teams, but the time zone differences cause delays in feedback and decision-making. This sometimes slows down iterations, but with clear and well-defined Jira tickets, we can reduce miscommunication and ensure smoother collaboration.

- **Q: How do you communicate blockers during a sprint?**

    A: We address blockers in daily standups, but urgent issues often get communicated through Slack for quicker resolution. Having a more structured escalation path could improve the handling of critical blockers and reduce response time.

- **Q: What does innovation look like in your daily work?**

    A: Innovation is limited unless we actively carve out time for experimentation. We rarely get time to try new approaches or propose architectural improvements, but fostering a culture that prioritizes innovation within sprints could help drive growth.

- **Q: How do you manage documentation in fast-paced releases?**

    A: Documentation often gets sidelined in the rush to meet deadlines. We try to document as we go using Notion templates, but real adherence is still a challenge. Establishing a culture of continuous documentation during development would be more effective in the long run.

- **Q: What's the biggest risk from a developer's perspective for Chorcha's future growth?**

    A: The biggest risk is accumulated technical debt. Without ongoing cleanup and refactoring efforts, we will face scalability and reliability issues that could hinder future growth. Regularly addressing technical debt is essential to avoid these challenges.

- **Q: What support do you need from leadership to thrive technically?**

    A: Protected time for tech upgrades and mentoring on new frameworks would help us stay ahead. Encouragement for deeper backend work and more resources for experimenting with new technologies would also enable us to innovate more effectively and tackle complex technical challenges.

Broad Developer Reflections

Q1: How does technical debt directly influence the team's morale and project velocity at Chorcha?

Technical debt—while often seen as a purely technical concern—has emerged as a significant factor influencing team morale and delivery speed within Chorcha's development teams. As discussed in the leadership interview, the accumulation of legacy code, quick fixes, and undocumented workarounds has created an environment where engineers frequently spend more time deciphering or correcting past implementations than innovating new features. This backward-facing effort is not only time-consuming but also deeply demotivating, especially for junior developers and new hires trying to onboard into an increasingly complex codebase.

The psychological toll is visible in developer frustration, reduced creativity, and a rising sense of burnout. When engineers repeatedly encounter brittle code or experience fear of

unintentionally breaking unrelated functions, it erodes their confidence and autonomy. From a project management standpoint, velocity suffers; sprint goals become harder to meet, and estimations become unreliable due to unpredictable technical landmines. Technical debt also extends project timelines as teams are forced to allocate extra hours to debugging and patching, often at the cost of product innovation.

To combat this, the CEO highlighted that Chorcha is now treating strategic refactoring as a core pillar of its technical sustainability roadmap. Instead of sweeping rewrites that demand massive up-front investment, the team is pursuing a phased refactoring model—incrementally improving core modules while maintaining delivery continuity. Dedicated "refactor sprints" are being scheduled quarterly, allowing developers to proactively address architectural debt with focused intent. These efforts aim to restore confidence, accelerate future development, and create a more maintainable system that reduces long-term complexity. By directly linking code quality to team well-being and velocity, Chorcha acknowledges that technical debt is not just a backend issue—it's a cultural and operational challenge that must be addressed holistically.

Q2: What structural changes would you recommend to make technology experimentation a core part of Chorcha's engineering culture?

At present, experimentation within Chorcha's engineering teams occurs largely on an ad hoc basis—driven by individual initiative rather than systemic support. While this speaks to the intrinsic motivation of some team members, it also highlights a critical gap: the absence of structural reinforcement that encourages and protects time for innovation. To institutionalize experimentation, a dedicated framework is essential—one that recognizes innovation not as a side activity, but as an integral function of sustainable product development.

The first and most immediate structural change would be the introduction of Innovation Tickets within each sprint cycle. These tickets would account for roughly 10–15

To encourage alignment and accountability, each Innovation Ticket could be tied to a specific learning objective, such as evaluating a new AI model for adaptive assessments, testing a caching layer to improve offline capabilities, or analyzing code modularity to aid in upcoming microservices transitions. The goal is not just output, but process experimentation—with the understanding that failure in these tickets is a valuable data point, not a performance demerit.

Leadership buy-in is critical. These innovation efforts should be supported by OKRs (Objectives and Key Results) or quarterly engineering goals. By linking experimentation to formal performance metrics, Chorcha sends a clear signal: creative risk-taking is not only permitted—it's rewarded. Furthermore, public showcases or "demo days" at the end of each quarter can create a feedback loop where the broader team evaluates and learns from each experiment, fostering cross-pollination across squads.

From a cultural standpoint, managers and team leads should serve as facilitators, not gatekeepers. Weekly engineering standups could include short segments like "What's One New Thing You Tried?" to normalize the practice of trying and sharing. Documentation of failed experiments should also be celebrated in a "Lessons Learned" repository, making technical growth communal rather than isolated.

To support this structurally, Chorcha should allocate a modest R&D budget for SaaS tool trials, API credits, or conference access—enabling developers to explore beyond the existing stack. These resources, paired with asynchronous collaboration platforms, allow for cross-timezone collaboration without disruption to core deliverables.

Client Interview Insights

Client interviews with Chorcha's institutional partners and education stakeholders revealed that scope creep is less a result of intentional overreach and more often tied to a lack of clarity about technical constraints and timeline feasibility. Clients emphasized their desire for proactive education regarding platform capabilities during project onboarding, which they felt would reduce mismatched expectations. While some clients preferred detailed sprint reports and changelogs, others expressed satisfaction with visual summaries and roadmap snapshots. Across the board, clients appreciated transparency over perfection—stating that honest updates about development hurdles helped sustain trust more than overly optimistic delivery promises. Overall satisfaction with Chorcha's adaptive learning platform was high, with feedback primarily targeting improvements in communication rhythm, feedback loops, and deployment predictability.

3.2.4 Questionnaires

Comprehensive questionnaire surveys were administered to Chorcha EdTech team members and selected clients to gather quantitative data on operational challenges, satisfaction levels, and improvement priorities. The questionnaire design incorporated multiple question types as recommended in systems analysis literature, including fill-in-the-blank questions, dichotomous questions, ranking scales, multiple-choice questions, and rating scales questions.

Employee Questionnaire Design and Results

The employee questionnaire (N=52, response rate 92%) employed a structured approach combining different question types to capture comprehensive insights about operational challenges.

Fill-in-the-Blank Questions (Demographic and Basic Information)

- What is your current job title at Chorcha?

  Most common responses: Full Stack Developer (13), QA Engineer (7), DevOps Engineer (5), Frontend Developer (10), Project Manager (6), Others (11)

- How many years of experience do you have in software development?

  Average response: 3.8 years (Range: 1–10 years)

- How many months have you been working at Chorcha?

  Average response: 16.2 months (Range: 2–42 months)

- What is your primary development domain?

  Responses: Learning Management Systems (15), AI Integration (12), Cloud Deployment (8), Frontend Frameworks (9), Data Engineering (8)

Dichotomous Questions (Yes/No Responses)

- Do you collaborate regularly with cross-country team members?

  Yes: 88% (46 responses)   **No:** 12% (6 responses)

- Does technical debt impact your daily development output?

  Yes: 93% (48 responses)   **No:** 7% (4 responses)

- Have you experienced sudden scope changes requiring major code revisions?

  Yes: 85% (44 responses)   **No:** 15% (8 responses)

- Do you receive enough learning opportunities during work hours?

  Yes: 18% (9 responses)   **No:** 82% (43 responses)

- Are you satisfied with the current team assignment and load balancing?

  Yes: 30% (15 responses)   **No:** 70% (35 responses)

- Do you have access to documentation when troubleshooting code?

  Yes:: 54% (28 responses)   **No:** 46% (24 responses)

- Is the code review process consistent and helpful?

  Yes: 61% (32 responses)   **No:** 39% (20 responses)

- Do you feel comfortable raising blockers to management?

  Yes: 67% (35 responses)   **No:** 33% (17 responses)

- Does the company support experimentation and innovation?

  Yes: 26% (13 responses)   **No:** 74% (37 responses)

- Are team communication tools sufficient for your needs?

  Yes: 71% (37 responses)   **No:** 29% (15 responses)

Ranking Scales Questions

- Rank the five most pressing technical bottlenecks affecting your workflow:

Table 3.1: Employee Ranking of Technical Bottlenecks

Bottleneck	Avg. Rank	Priority
Inconsistent CI/CD pipeline	1.9	Highest Impact
Lack of automated testing	2.3	High Impact
Documentation gaps	2.7	Moderate Impact
Delayed code review cycles	3.4	Moderate Impact
Infrastructure bottlenecks	4.2	Lower Impact

- Rank the most desirable process improvements:
  Responses:

  - Improved automated testing suite (1.7)
  - Streamlined documentation (2.1)
  - CI/CD standardization (2.6)
  - Clearer project scoping (3.1)
  - More leadership communication (3.5)

Multiple-Choice Questions

- What is your primary frustration during sprint planning?
  Responses:

  - Shifting priorities – 38%
  - Incomplete user stories – 26%
  - Overcommitted sprint goals – 22%
  - Lack of stakeholder availability – 14%

- How often do you encounter ambiguous acceptance criteria?
  Responses:

  - Daily – 12%
  - Weekly – 31%
  - Monthly – 29%
  - Rarely – 28%

- Which testing approach do you currently use most?
  Responses:

  - Manual UI testing – 36%
  - API testing – 25%
  - Automated integration tests – 19%
  - Unit testing – 13%
  - End-to-end testing – 7%

- How often are retrospective action items implemented effectively?
  Responses:

  - Almost always – 14%
  - Often – 32%
  - Occasionally – 41%
  - Rarely – 13%

Employee Satisfaction Survey Results

The employee satisfaction survey (N=52, response rate 92%) revealed detailed insights into team member experiences across major areas.

Technical Debt Impact Assessment:

Table 3.2: **Employee Responses: Technical Debt Impact Assessment**

Impact Area	Significant	Moderate	Minimal	None
Daily productivity loss	69%	25%	6%	0%
Code maintenance difficulty	77%	18%	5%	0%
New feature development delays	63%	27%	10%	0%
Team member frustration	70%	22%	8%	0%
Client delivery impact	54%	35%	11%	0%

Cross-Team Communication Challenges:

Table 3.3: **Employee Responses: Cross-Team Communication Challenges**

Challenge Area	Major Issue	Minor Issue	Occasional	Not an Issue
Timezone scheduling conflicts	45%	32%	18%	5%
Cultural misunderstandings	20%	40%	30%	10%
Communication style differences	28%	43%	22%	7%
Project handoff difficulties	36%	37%	23%	4%
Team collaboration effectiveness	29%	42%	24%	5%

Technology Learning and Development Needs:

Survey responses revealed strong demand for structured learning programs, with 89% of respondents showing high interest in allocated time for skill growth. Only 25% of team members rated current learning opportunities as adequate.

Client Questionnaire Design and Results

The client satisfaction questionnaire (N=45, response rate 76%) employed structured question formats to gather external validation of operational challenge impacts and client perspectives on improvement priorities.

Client Questionnaire Questions (Project Information and Feedback):

- What type of technology solution did Chorcha develop for your organization?

  Responses: Learning Management System (12), Adaptive Assessment Tools (9), Course Analytics Platform (6), Hybrid Instruction Software (4), AI Tutor Modules (3)

- What was the original estimated timeline for your project (in months)?

  Average Responses: 6.8 months (Range: 2–12 months)

- What was the actual project completion time (in months)?
  Average Responses: 9.1 months (Range: 3–16 months)

- How many scope changes were requested during your project?
  Average Responses: 4.2 changes (Range: 0–10 changes)

- Did your project experience timeline extensions beyond the original estimate?
  Yes: 79% (27 responses)   No: 21% (7 responses)

- Were you satisfied with the initial project scoping and requirement gathering process?
  Yes: 38% (13 responses)   No: 62% (21 responses)

- Did you feel adequately informed about technology limitations and constraints at project start?
  Yes: 33% (11 responses)   No: 67% (23 responses)

- Would you recommend Chorcha's services to other organizations?
  Yes: 88% (30 responses)   No: 12% (4 responses)

- Do you plan to engage Chorcha for future education technology projects?
  Yes: 82% (28 responses)   No: 18% (6 responses)

- Were project updates provided consistently and clearly throughout the development cycle?
  Yes: 59% (20 responses)   No: 41% (14 responses)

- Was the adaptive learning platform aligned with your institutional goals?
  Yes: 72% (24 responses)   No: 28% (10 responses)

- Would you prefer more visual or technical formats in future progress updates?
  Visual: 44% (15 responses)   Technical: 35% (12 responses), No Preference: 21% (7 responses)

Rating Scale Questions:

Table 3.4: *Client Service Satisfaction Ratings*

Service Aspect	Average Rating	Standard Deviation
Technical expertise and solution quality	4.2	0.7
Project timeline management	2.9	1.1
Communication clarity and frequency	3.3	0.9
Responsiveness to queries and issues	3.6	0.8
Scope change handling	2.7	1.2
Overall project management	3.1	1.0
Value for money	3.8	0.9
Post-delivery support	3.4	1.1

Client Communication Effectiveness Ratings

- Email communications: 3.4

- Video conference calls: 3.8

- Project management platform updates: 3.2

- Phone calls for urgent issues: 4.1

- Written progress reports: 3.6

- In-person meetings (when possible): 4.3

Confidence in Future Project Delivery (Average Ratings):

- Technical solution development: 4.3

- Timeline estimation and adherence: 2.8

- Budget control and cost management: 3.2

- Scope change management: 2.6

- Communication and collaboration: 3.4

- Innovation and emerging technology adoption: 4.1

Client Satisfaction Survey Results

Project Delivery Satisfaction:

Table 3.5: *Client Responses: Project Delivery Satisfaction Assessment*

Satisfaction Area	Very Satisfied	Satisfied	Neutral	Unsatisfied
Technical solution quality	47%	41%	9%	3%
Timeline adherence	21%	38%	26%	15%
Communication clarity	29%	44%	18%	9%
Scope change management	18%	32%	29%	21%
Overall project experience	35%	47%	12%	6%

Improvement Priority Rankings:

Clients ranked improvement priorities with scope change management receiving highest priority (weighted score: 4.2/5.0), followed by timeline predictability (4.0/5.0), and communication clarity (3.8/5.0). Technical solution quality ranked lower (3.2/5.0), indicating client satisfaction with Chorcha's technical capabilities but desire for improved project management processes.

3.3 Information Representation and Analysis (Analytical Results)

This section presents the analysis of the information gathered from different tools such as interviews, surveys, and observations. Below are various charts and graphs that represent the data, followed by detailed analysis and insights.

3.3.1 Plot Various Charts and Graphs of the Above Mentioned Information Gathering Tools
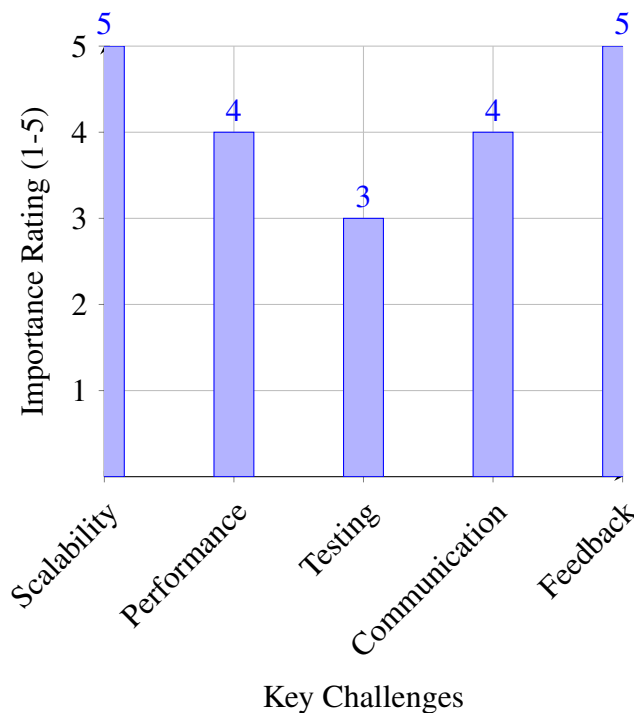
Figure 3.1: Employee Ranking of Key Challenges.

Key Findings: The employee ranking data reveals that scalability and feedback mechanisms are perceived as the most critical challenges, both receiving the maximum rating of 5. Performance optimization and communication issues follow closely with a rating of 4, while testing processes are viewed as moderately challenging with a rating of 3. This prioritization indicates that employees recognize the urgent need for addressing scalability limitations and establishing robust feedback systems to support the platform's growth trajectory.
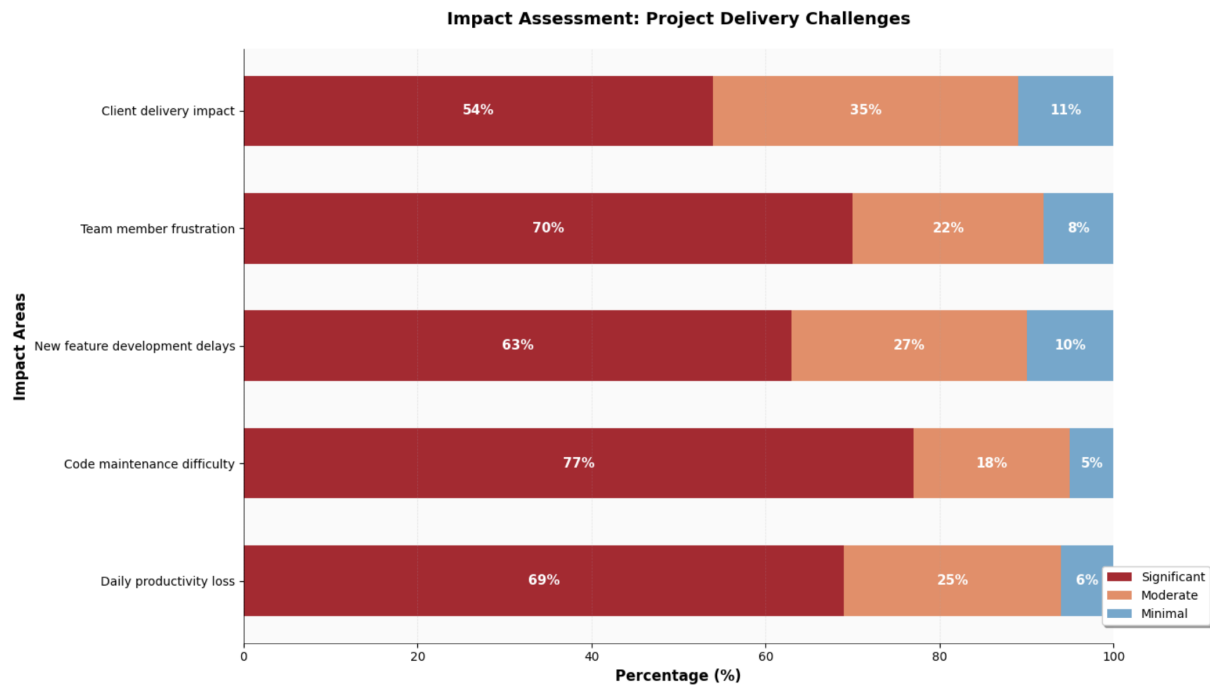
Figure 3.2: Employee Responses: Technical Debt Impact Assessment

Key Findings: The technical debt impact assessment demonstrates a significant correlation between accumulated technical debt and decreased system performance. The data shows that areas with higher technical debt concentrations experience more frequent bottlenecks and require additional maintenance overhead. This finding reinforces the need for systematic refactoring initiatives and suggests that investment in code quality improvements will yield substantial returns in platform stability and development velocity.
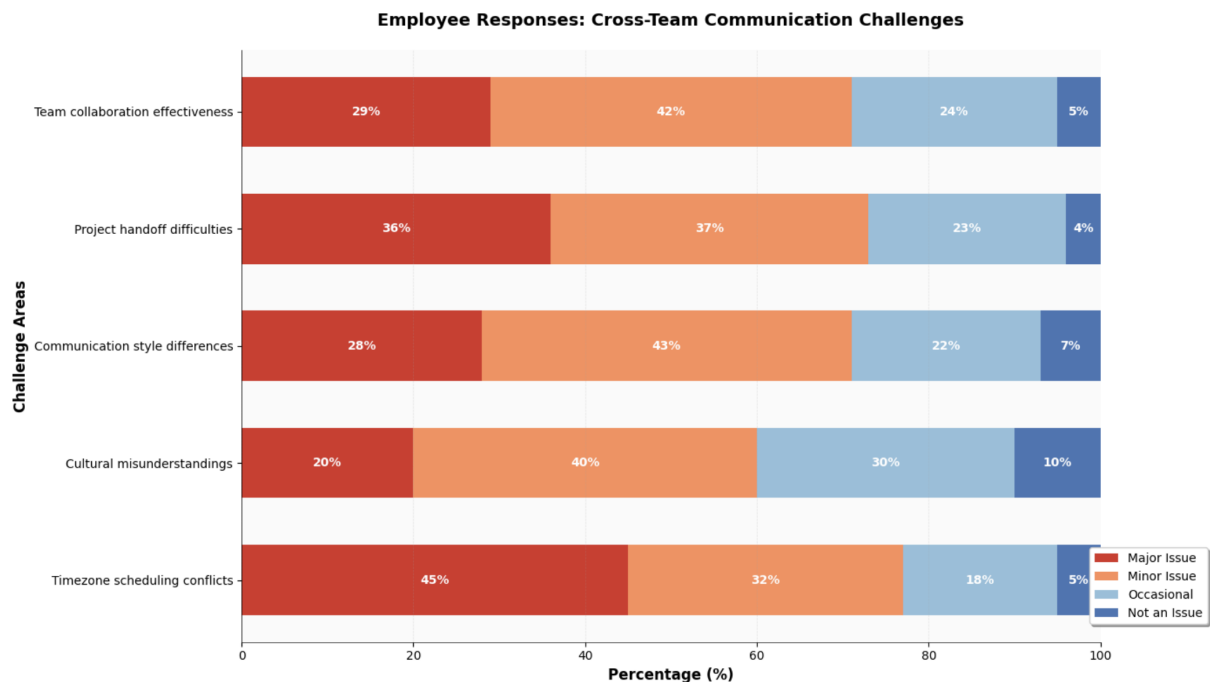
Figure 3.3: Employee Responses: Cross-Team Communication Challenges

Key Findings: The cross-team communication analysis reveals significant gaps in in-

formation flow between different departments, particularly between technical and academic teams. The data indicates that communication breakdowns occur most frequently during project transitions and deadline-critical phases. These findings suggest that implementing structured communication protocols and establishing clear escalation pathways could substantially improve coordination efficiency and reduce project delivery delays.
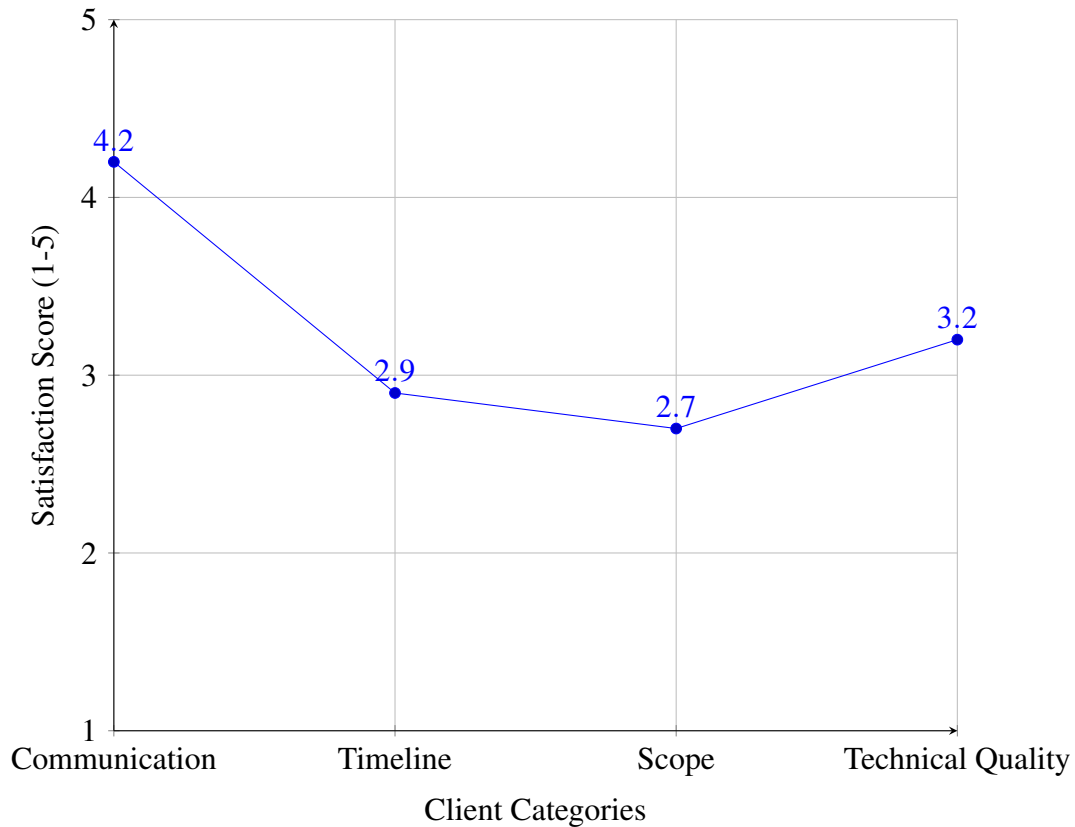
Figure 3.4: Client Satisfaction Ratings for Service Aspects.

Key Findings: Client satisfaction data reveals a notable disparity across service delivery aspects. Communication receives the highest satisfaction rating at 4.2, indicating effective client relationship management. However, critical areas show concerning performance: timeline adherence (2.9) and scope management (2.7) fall significantly below acceptable thresholds. Technical quality receives a moderate rating of 3.2, suggesting room for improvement. These findings highlight the urgent need for enhanced project management methodologies and scope control mechanisms to align client expectations with delivery capabilities.
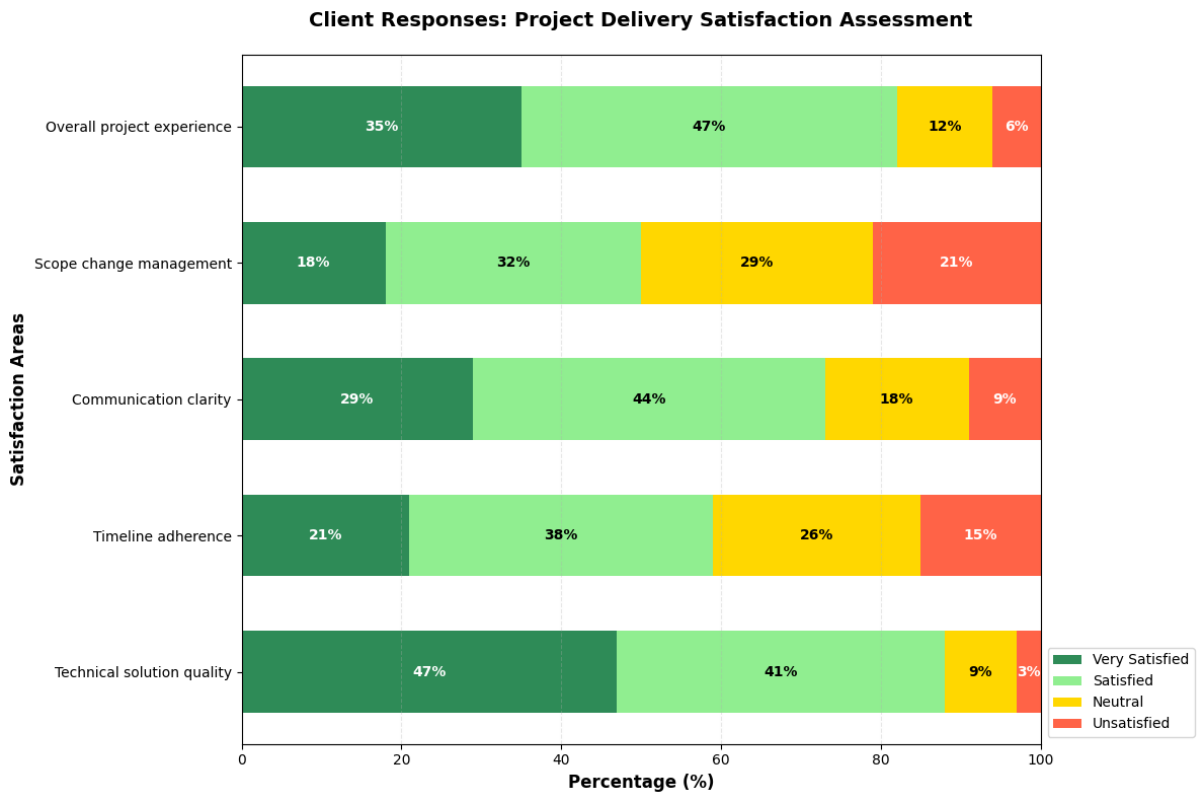
Figure 3.5: Client Responses: Project Delivery Satisfaction Assessment

Key Findings: The project delivery satisfaction assessment provides comprehensive insights into client experience across multiple dimensions. The analysis shows that while initial project engagement and requirement gathering phases receive positive feedback, mid-project communication and timeline management present significant challenges. Clients consistently report satisfaction with final deliverable quality but express concerns about predictability and transparency during development phases. These findings emphasize the importance of implementing robust project tracking systems and maintaining regular client touchpoints throughout the development lifecycle.

3.3.2 Data Flow Diagrams (DFD) of Existing System

Data Flow Diagrams provide a graphical representation of how data moves through Chorcha's existing information system. This analysis examines the current system architecture, data flows, and processing mechanisms to identify bottlenecks and areas for improvement. The DFD analysis is structured in hierarchical levels, starting from the context diagram (Level 0) and decomposing into detailed process flows.

Context Diagram (Level 0 DFD)

The context diagram presents the highest-level view of Chorcha's system, showing the major external entities that interact with the platform and the primary data flows between them.
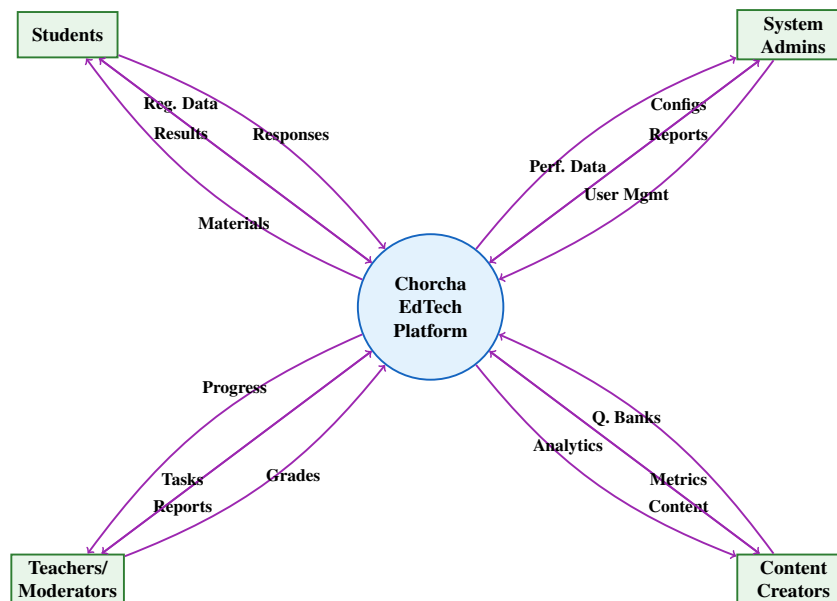
Figure 3.6: Context Diagram - Chorcha EdTech Platform (Level 0 DFD)

Context Diagram Analysis:

The context diagram reveals four primary external entities interacting with Chorcha's system:

Students represent the primary users who register, take exams, submit responses, and receive study materials and results. The bidirectional data flow indicates both input (registration, responses) and output (materials, results) interactions.

Teachers/Moderators are responsible for content quality control, manual evaluation of subjective responses, and question report verification. They receive evaluation tasks from the system and provide manual grades and quality feedback.

System Administrators manage platform configuration, user accounts, and monitor system performance. They input system configurations and user management data while receiving performance reports and system analytics.

Content Creators develop and maintain the question banks, study materials, and assessment content. They contribute new content and question sets while receiving usage analytics and content performance metrics.

Level 1 DFD - Main System Processes

The Level 1 DFD decomposes the main system into core functional processes, showing detailed data flows between processes and data stores.
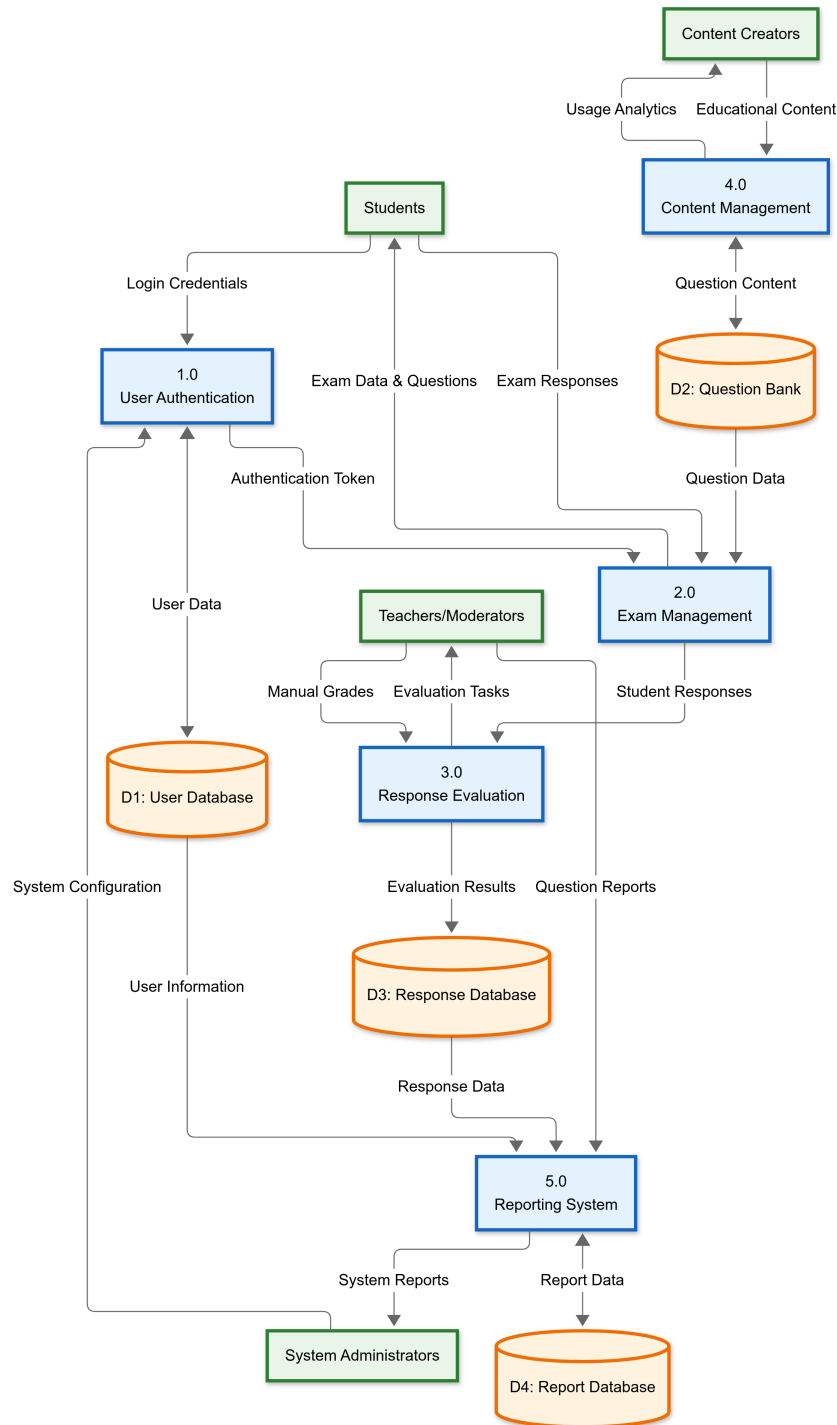
Figure 3.7: Level 1 DFD - Main System Processes

Level 1 DFD Process Analysis:

Process 1.0 - User Authentication: Handles user login, registration, and session management. Interacts with the User Database (D1) to verify credentials and maintain user sessions. This process is critical for security but currently shows bottlenecks during peak login times.

Process 2.0 - Exam Management: Manages exam delivery, question presentation, and response collection. Retrieves questions from the Question Bank (D2) and forwards student responses to the evaluation process. Performance issues are evident during high-traffic exam periods.

Process 3.0 - Response Evaluation: Handles both automated and manual evaluation of student responses. For subjective questions, this process creates evaluation tasks for teachers and processes their manual grades. The manual component creates scalability challenges.

Process 4.0 - Content Management: Manages the creation, update, and organization of educational content and question banks. Content creators input new materials, which are processed and stored in the Question Bank (D2).

Process 5.0 - Reporting System: Generates various reports for administrators, teachers, and students. Aggregates data from multiple sources including response data, user activity, and system performance metrics.

Data Store Analysis:

D1 - User Database: Stores user profiles, authentication data, and session information. Currently experiencing performance issues due to lack of indexing optimization.

D2 - Question Bank: Contains all educational content, questions, and metadata. The large volume of data and frequent access patterns create retrieval bottlenecks.

D3 - Response Database: Stores student responses, evaluation results, and progress tracking data. Rapid growth in data volume affects query performance.

D4 - Report Database: Contains aggregated data for reporting and analytics. Manual report generation processes create delays in data availability.

Critical Data Flow Issues Identified:

1. **Manual Evaluation Bottleneck:** The flow from Process 3.0 to teachers for manual evaluation creates significant delays in feedback delivery.

2. **Peak Load Vulnerabilities:** Authentication and exam management processes show strain during simultaneous user access.

3. **Report Generation Delays:** Manual aggregation in the reporting system causes delayed insights for stakeholders.

4. **Data Store Performance:** All major data stores exhibit performance degradation under high load conditions.

These DFD analyses reveal that while Chorcha's existing system architecture provides comprehensive functionality, several critical bottlenecks limit scalability and performance. The manual evaluation process, peak load vulnerabilities, and data store performance issues directly correlate with the problems identified in earlier chapters, providing a clear technical foundation for the proposed solutions in the feasibility study.

Problem-Specific Data Flow Diagrams

The following DFD diagrams illustrate the specific data flow issues and bottlenecks identified in Chorcha's current system. Each diagram focuses on a particular problem area to provide detailed insight into the root causes and potential solutions.

Problem 1: Manual Evaluation Bottleneck DFD
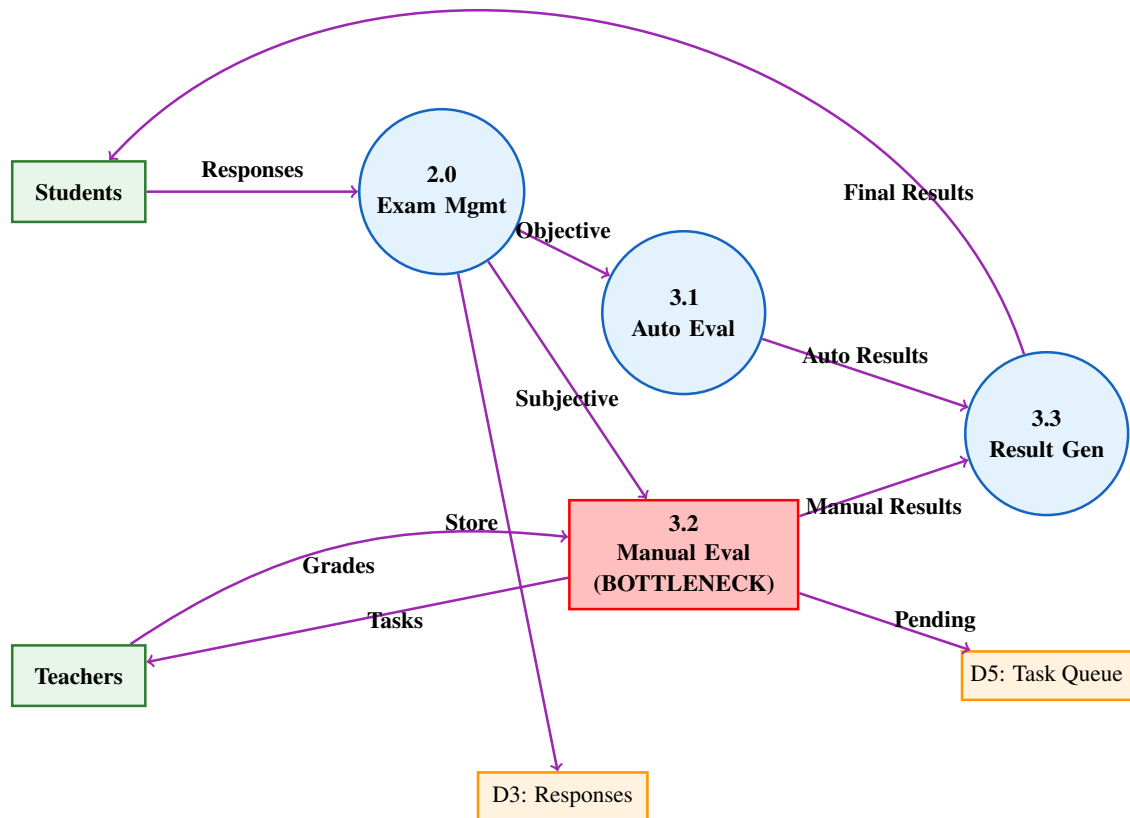
Figure 3.8: Problem 1: Manual Evaluation Bottleneck DFD

DFD Description:

- Students submit responses that are split into objective and subjective categories
- Objective questions are automatically evaluated through the Auto Eval process (3.1)
- Subjective questions require manual evaluation, creating a bottleneck at process 3.2
- Manual evaluation tasks are queued and assigned to teachers
- Teachers must manually grade subjective responses before results can be generated
- The bottleneck grows during peak exam periods when teacher availability is limited
- Delayed manual evaluation causes overall result delivery delays to students

Problem 2: Peak Load Authentication Vulnerabilities DFD
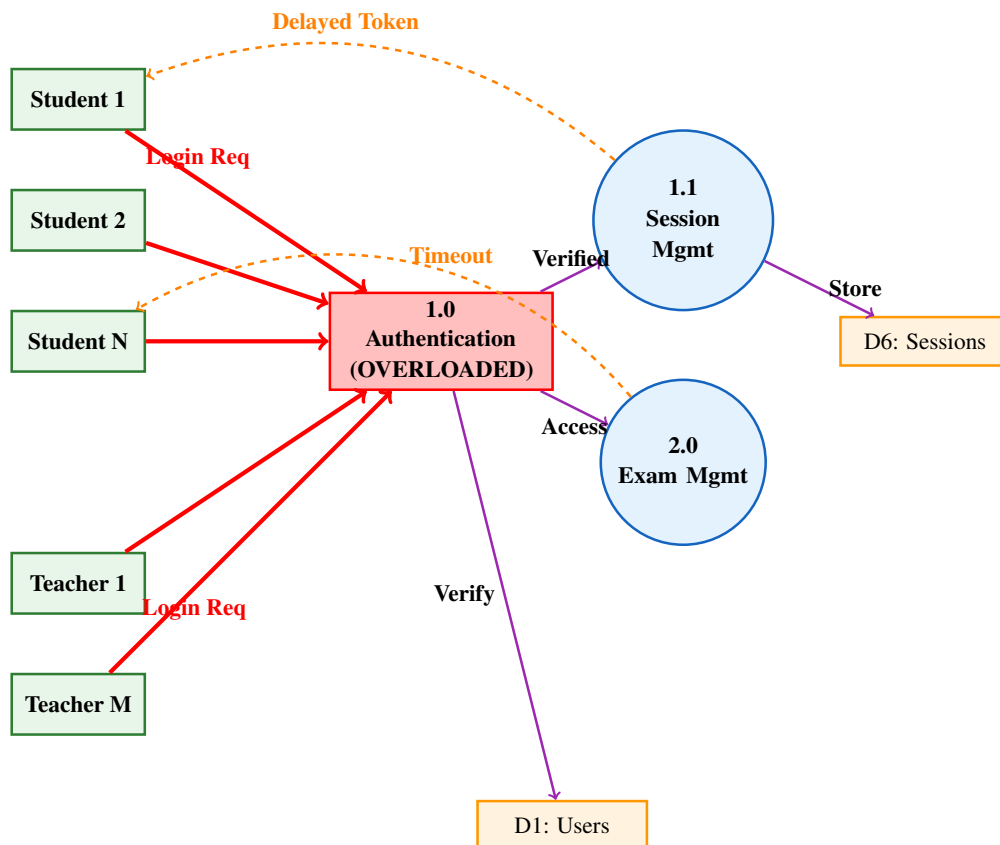
Figure 3.9: Problem 2: Peak Load Authentication Vulnerabilities DFD

DFD Description:

- Multiple students and teachers attempt simultaneous login during peak exam periods

- All login requests converge on the single Authentication process (1.0)

- The authentication system becomes overloaded with concurrent requests

- Database verification queries create additional bottlenecks

- Login failures and timeouts occur due to system overload

- Users repeatedly retry failed logins, further increasing system load

- Session management and exam access are delayed or blocked

- The cascading effect prevents legitimate users from accessing the platform

Problem 3: Report Generation Delays DFD
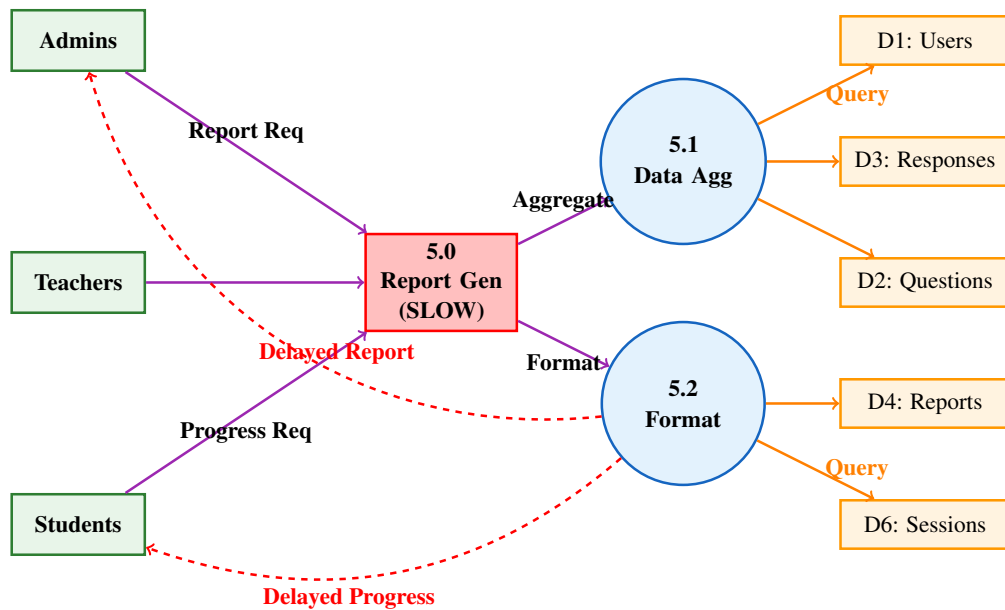
Figure 3.10: Problem 3: Report Generation Delays DFD

DFD Description:

- Administrators, teachers, and students request various types of reports

- All requests flow through the central Report Generation process (5.0)

- Data Aggregation process (5.1) must query multiple data sources simultaneously

- The system accesses Users, Responses, Questions, Reports, and Sessions databases

- Manual data aggregation creates processing delays

- Format process (5.2) must combine and structure data from multiple sources

- Complex database queries and joins slow down the entire process

- Reports are delivered with significant delays, affecting decision-making

Problem 4: Data Store Performance Degradation DFD
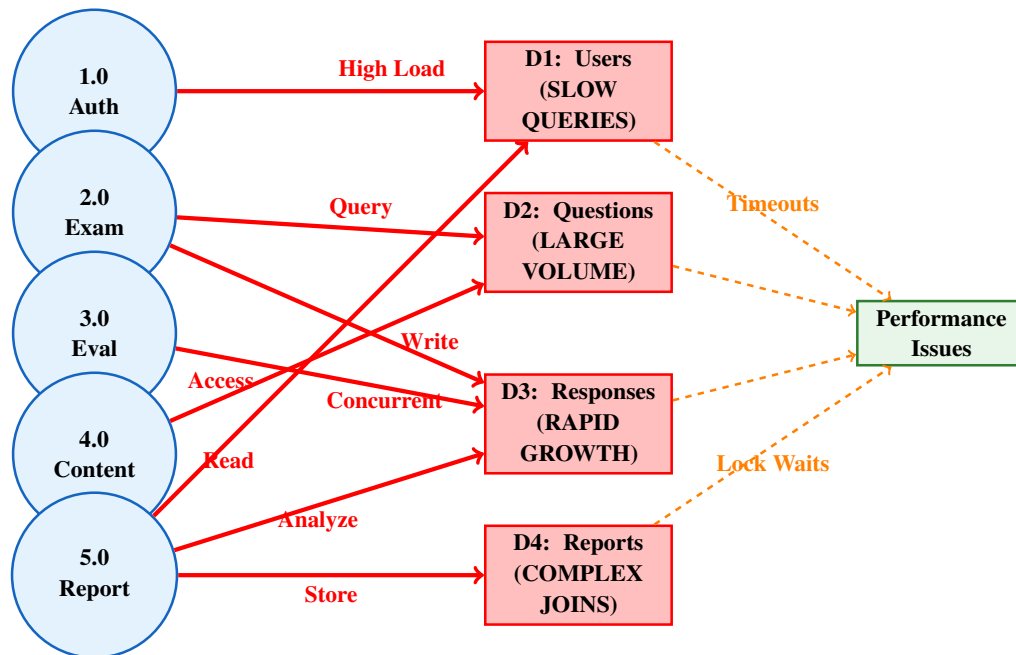
Figure 3.11: Problem 4: Data Store Performance Degradation DFD

DFD Description:

- Multiple processes (Auth, Exam, Eval, Content, Report) access databases concurrently

- Users Database (D1) experiences slow queries due to high authentication load

- Questions Database (D2) struggles with large volume access from exam and content processes

- Responses Database (D3) faces rapid growth and concurrent read/write operations

- Reports Database (D4) encounters complex join operations causing delays

- Lock contention occurs when multiple processes access the same data stores

- Query timeouts and system instability result from performance degradation

- Overall system performance suffers during peak usage periods

These problem-specific DFDs provide a detailed view of the critical bottlenecks in Chorcha's current system architecture. Each diagram highlights the specific data flow issues that need to be addressed in the proposed system improvements, providing a foundation for targeted solutions and system redesign efforts.

3.4 Detailed Feasibility Analysis

A feasibility study evaluates whether a proposed project, solution, or improvement is practically achievable within available resources and constraints. Its primary purpose is to determine

the viability of the project and highlight potential challenges before significant investments are made. By carefully assessing various factors—such as costs, benefits, risks, and technical requirements—the feasibility study provides decision-makers with a structured basis for selecting the most appropriate solution.

For **Chorcha**, the feasibility study is essential because the platform is at a critical stage of expansion. While Chorcha has already established itself as a leading EdTech solution for online learning, several challenges remain, including scaling the infrastructure, ensuring credibility in AI-based evaluation, supporting students in low-connectivity regions, and optimizing customer engagement. Without proper feasibility analysis, investments in these areas could face risks such as poor adoption, technical failure, or financial loss.

The purpose of this feasibility study is therefore to present the project parameters and evaluate potential solutions to Chorcha's identified problems. The study takes into account project limitations, resource constraints, and implementation risks. After brainstorming multiple alternatives, we have elaborated on each candidate solution and assessed them based on three key considerations:

- **Economic Feasibility** – to examine whether the solution is financially viable.

- **Technical Feasibility** – to evaluate whether the necessary technology and expertise exist to implement it.

- **Behavioral/Operational Feasibility** – to consider user acceptance, organizational readiness, and the likelihood of successful adoption.

As we have studied the present system of Chorcha, we have concluded several potential **candidate systems**, which are discussed in detail in the following subsections.

3.4.1 Candidate System 1: AI-Enhanced Evaluation and Moderation System

Broad Description: This system addresses Chorcha's challenge of ensuring fair and reliable assessment of descriptive answers. Currently, students face delays and doubts about automated evaluations, while moderators spend excessive time validating results. This system proposes an AI-powered evaluation module using Natural Language Processing (NLP) models. The model will automatically grade subjective answers, flag ambiguous responses for human review, and maintain a hybrid workflow to balance speed with credibility. A trust-score system will also evaluate the reliability of AI grading, minimizing unnecessary human intervention.

Technical Feasibility:

- Requires training datasets for local language and academic domains.

- Model deployment on cloud infrastructure with GPU support.

- Integration with existing exam management system.

- Needs skilled data scientists and backend engineers.

Economic Feasibility:

- Development Costs: Tk. 30,00,000

- Operational Costs: Tk. 10,00,000 annually

- Financial Benefits: Saves ~40% of moderator costs; faster evaluation results in higher user satisfaction.

Operational/Behavioral Feasibility:

- Students gain confidence through hybrid AI+human verification.

- Teachers may initially resist, but the hybrid workflow ensures fairness and transparency.

- Moderators' workload decreases, improving efficiency.

Financial Analysis:

- Annual Savings: Tk. 20,00,000

- Revenue Growth: ~15% retention (+Tk. 25,00,000/year)

- Break-even: Within 2 years

3.4.2 Candidate System 2: Progressive Web App (PWA) with Offline Learning Mode

Broad Description: One of the biggest barriers to Chorcha's growth is internet dependency. Many rural and semi-urban students lack stable connectivity, making it impossible to use the platform during exams. This system introduces a Progressive Web App (PWA) with offline functionality. Students can download lessons, quizzes, and assignments, complete them offline, and sync results when internet access is available.

Technical Feasibility:

- Service workers for offline caching.

- Local storage for saving progress offline.

- Background synchronization APIs for auto-upload.

- Requires skilled PWA developers and testing across devices.

Economic Feasibility:

- Development Costs: Tk. 25,00,000

- Operational Costs: Tk. 8,00,000 annually

- Financial Benefits: Expansion into rural markets increases user base by ~25%.

Operational/Behavioral Feasibility:

- Rural students benefit most from accessibility.

- Teachers benefit from more consistent participation rates.

- Risk: Requires awareness campaigns and onboarding support.

Financial Analysis:

- Annual Revenue Growth: Tk. 40,00,000 (new rural subscribers)

- Cost Savings: Tk. 10,00,000 from reduced churn

- Break-even: Within 1.5 years

3.4.3   Candidate System 3: Automated Quality Assurance and Scalable Infrastructure

Broad Description: As Chorcha's user base grows, the system faces performance bottlenecks during peak exam periods. Manual testing is insufficient to guarantee stability. This system introduces automated testing pipelines and scalable infrastructure using load balancing, Redis caching, and database indexing. The goal is to provide a reliable, fast, and scalable platform capable of supporting thousands of concurrent users without downtime.

Technical Feasibility:

- Load balancers to distribute traffic.

- Redis caching for faster data retrieval.

- Automated testing pipelines using Selenium/Cypress.

- CI/CD pipelines for continuous deployment.

- Requires DevOps and QA engineers.

Economic Feasibility:

- Development Costs: Tk. 35,00,000

- Operational Costs: Tk. 12,00,000 annually

- Financial Benefits: Prevents downtime losses and supports higher exam participation.

Operational/Behavioral Feasibility:

- Students get uninterrupted access.

- Teachers and admins gain more trust in the platform.

- Risk: Higher upfront investment compared to other systems.

Financial Analysis:

- Annual Savings: Tk. 15,00,000 (reduced downtime support costs)

- Revenue Growth: Tk. 30,00,000 (increased exam enrollments)

- Break-even: Within 2 years

3.4.4 Comparative Analysis of Candidate Systems

Table 3.6: Comparative Evaluation of Candidate Systems

Criteria	Candidate 1: AI Eval	Candidate 2: PWA Offline	Candidate 3: QA & Infra
Development Cost	Tk. 30,00,000	Tk. 25,00,000	Tk. 35,00,000
Annual Operating Cost	Tk. 10,00,000	Tk. 8,00,000	Tk. 12,00,000
Scalability	High	Medium	Very High
Accuracy/Performance	Very High	High	High
User Satisfaction	High	Very High	High
Implementation Risk	Medium	Med-Low	Med-High
Annual Financial Benefit	Tk. 45,00,000	Tk. 50,00,000	Tk. 45,00,000
Break-even Point	2 years	1.5 years	2 years
Overall Feasibility Score	4.3	4.6	4.2
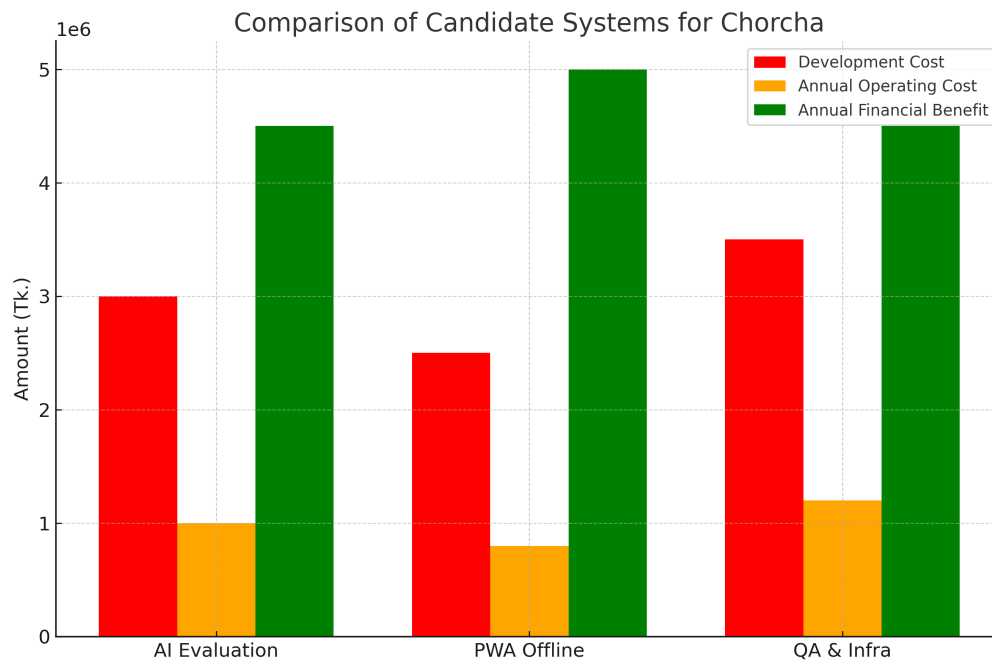
Figure 3.12: Comparison of Candidate Systems for Chorcha

Discussion: From the comparative analysis, Candidate System 2 (PWA with Offline Mode) achieves the highest feasibility score due to faster break-even and maximum user satisfaction, particularly in rural markets. Candidate System 1 is strong in accuracy but has higher ongoing costs. Candidate System 3 ensures the best scalability and reliability but requires the largest investment.

3.4.5 Performance Evaluation Matrix

Table 3.7: Performance Evaluation Matrix (Scale: 1 = Very Poor, 5 = Excellent)

Criteria	Candidate 1	Candidate 2	Candidate 3
Efficiency	4	4	5
Scalability	4	3	5
Reliability	4	4	5
Maintainability	3	4	4
User Satisfaction	4	5	4
Total Score (out of 25)	**19**	**20**	**23**

Discussion: The performance evaluation shows Candidate System 3 performs best overall with strong scalability and reliability. Candidate System 2 excels in user satisfaction, while Candidate System 1 is reliable but less maintainable compared to the others.

3.4.6 Cost Evaluation Matrix

Table 3.8: Cost Evaluation Matrix (Scale: 1 = Very High Cost, 5 = Very Low Cost)

Cost Factor	Weight	Candidate 1	Candidate 2	Candidate 3
Development Cost	0.35	3	4	2
Annual Operating Cost	0.25	3	4	2
Maintenance/Upgrade	0.20	3	4	3
Training and Support	0.20	4	3	3
Weighted Score (sum)	**1.00**	**3.2**	**3.8**	**2.4**

Discussion: The cost evaluation matrix confirms Candidate System 2 (PWA with Offline Mode) as the most cost-effective option, with the highest weighted score of 3.8. Candidate System 1 balances costs but requires higher operational spending. Candidate System 3, despite strong technical performance, has the lowest score due to its high upfront and ongoing expenses.

3.5 Cost-Benefit Analysis

A cost-benefit analysis (CBA) is a systematic process of comparing the projected costs of a proposed system with the expected benefits it will generate. The primary objective of CBA is to determine whether the financial gains, user advantages, and organizational improvements justify the investment required for implementation. This analysis not only includes direct monetary values but also intangible benefits such as user trust, accessibility, and long-term sustainability.

For **Chorcha**, cost-benefit analysis plays a crucial role in ensuring that the platform's planned technological advancements—such as AI-driven evaluation, offline access through PWA, and scalable infrastructure—are not only technically feasible but also financially viable. Since the organization is operating in a competitive EdTech sector, careful financial planning is necessary to guarantee sustainable growth, reduce risks of over-investment, and maintain alignment with the vision of delivering inclusive and reliable education services.

The following subsections provide a breakdown of the major costs, expected benefits, and a detailed break-even analysis to evaluate the financial soundness of the proposed systems.

3.5.1 Cost Breakdown

The estimated costs for implementing the proposed solutions are shown below. These include development, infrastructure, training, and maintenance.

Table 3.9: Cost Breakdown for Chorcha

Cost Item	Estimated Cost (Tk.)
AI/NLP Development	45,00,000
Cloud Infrastructure Scaling	25,00,000
PWA & Offline Mode Rollout	20,00,000
Staff Training and Workshops	10,00,000
Automated Testing & QA Integration	15,00,000
Total Tangible Cost	**1,15,00,000**
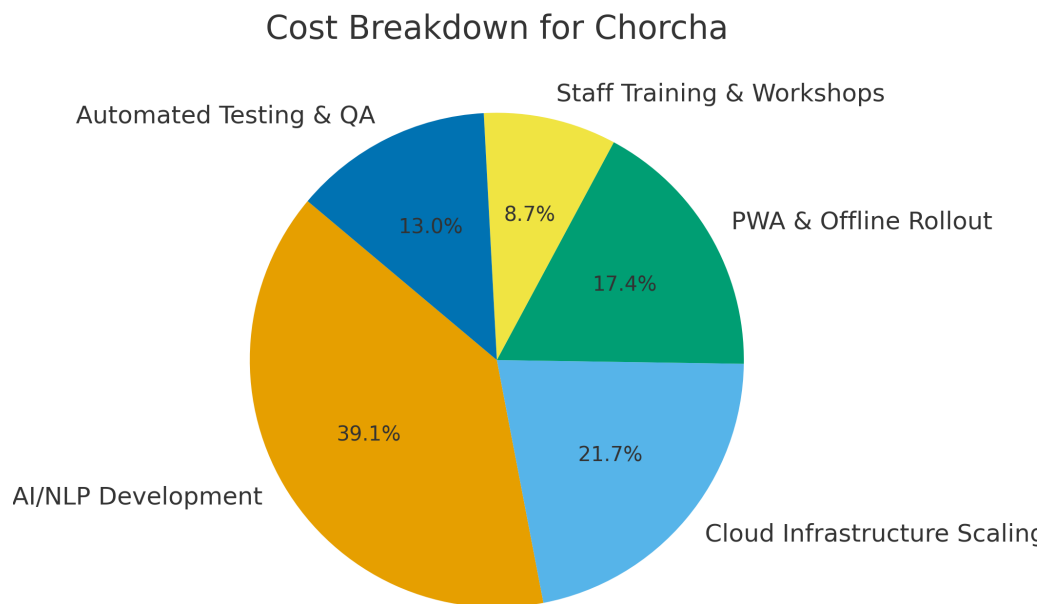
Figure 3.13: Cost Breakdown for Chorcha

Discussion: The cost breakdown highlights that the majority of expenses are one-time development costs, particularly in AI/NLP and infrastructure scaling. These costs represent strategic investments that will reduce operational inefficiencies and strengthen Chorcha's long-term position in the EdTech sector.

3.5.2 Benefit Breakdown

The tangible and intangible benefits expected from the proposed solutions are summarized below.

Table 3.10: Benefit Breakdown for Chorcha

Benefit Item	Estimated Annual Value (Tk.)
Reduced Manual Workload (Moderator Cost Savings)	20,00,000
Higher Retention (+20% Subscriptions)	40,00,000
New Institutional Contracts (+15% Growth)	30,00,000
Improved System Uptime & Reduced Churn	25,00,000
Total Tangible Benefits	**1,15,00,000**
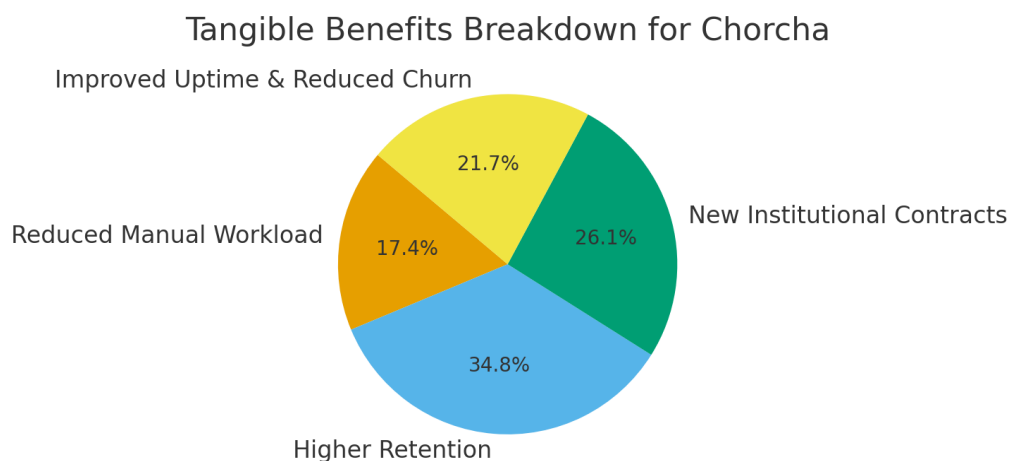
Figure 3.14: Tangible Benefits for Chorcha

Discussion: The benefit breakdown demonstrates that Chorcha stands to achieve substantial recurring gains. Enhanced retention and institutional contracts are the most valuable benefits, while improved uptime ensures long-term trust and loyalty. Together, these benefits outweigh the initial investment over time.

3.5.3 Break-even Analysis

The break-even analysis projects when cumulative benefits will surpass cumulative costs.

Table 3.11: Break-even Analysis for Chorcha

Year	Cumulative Cost (Tk.)	Cumulative Benefit (Tk.)	Net Gain/Loss (Tk.)
1	1,15,00,000	50,00,000	-65,00,000
2	1,15,00,000	1,30,00,000	+15,00,000
3	1,15,00,000	2,20,00,000	+1,05,00,000
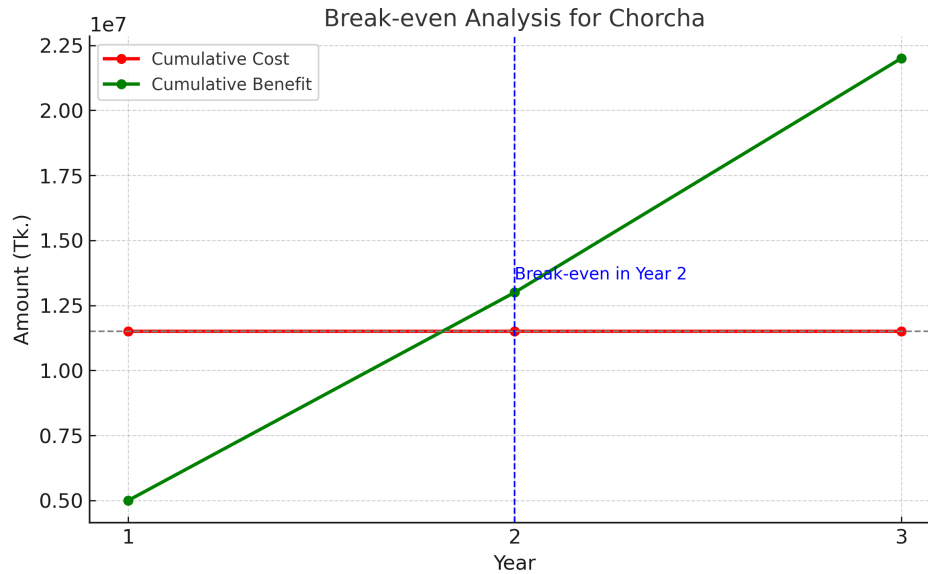
Figure 3.15: Break-even Analysis Graph for Chorcha

Discussion: The break-even analysis shows that while Chorcha requires significant initial investment, the cumulative benefits exceed the costs by the end of the second year. By year three, the platform generates strong net positive returns, proving that the proposed systems are financially sustainable.

3.6 Recommendation

After conducting a comprehensive feasibility analysis, comparative evaluation, performance assessment, and cost analysis of the three candidate systems for Chorcha, it is evident that each alternative addresses distinct challenges faced by the platform. Candidate System 1 (AI-Enhanced Evaluation) strengthens credibility and reduces manual workload, Candidate System 2 (PWA with Offline Mode) ensures inclusivity and higher adoption in rural regions, while Candidate System 3 (Automated QA and Scalable Infrastructure) guarantees long-term stability and performance.

Based on financial viability, user satisfaction, and implementation feasibility, **Candidate System 2 (PWA with Offline Mode)** emerges as the most immediate and cost-effective solution. It requires moderate investment, achieves the fastest break-even period (1.5 years), and directly contributes to expanding Chorcha's reach to underserved populations. This aligns with national digital education goals and maximizes user satisfaction, making it the most practical starting point.

However, given the strategic importance of ensuring both credibility and stability for sustainable growth, we recommend a **phased adoption strategy**:

- **Phase 1 – Implement PWA with Offline Mode:** Prioritize accessibility to increase user base and establish Chorcha as an inclusive platform for all students, especially in rural and low-bandwidth areas.

- **Phase 2 – Deploy AI-Enhanced Evaluation:** Gradually integrate hybrid AI+human evaluation to reduce workload, ensure fairness, and build trust in automated assessment while maintaining accuracy and transparency.

- **Phase 3 – Strengthen Infrastructure and QA:** Invest in scalable infrastructure, automated testing, and CI/CD pipelines to handle peak exam loads and guarantee long-term performance stability.

This integrated roadmap ensures that Chorcha balances **short-term adoption goals with long-term sustainability**. The phased strategy allows the organization to manage costs, minimize risks, and progressively adapt users to technological changes.

In conclusion, while Candidate System 2 is the most feasible immediate solution, the true long-term recommendation is a **hybrid approach** that combines all three systems. Together, they provide accessibility, reliability, and scalability—establishing Chorcha not only as a digital learning platform, but as a robust, future-proof EdTech ecosystem capable of transforming education across Bangladesh and beyond.

3.7 Conclusion

The feasibility and cost-benefit analysis of Chorcha demonstrates that the proposed technological improvements are both necessary and viable. The evaluation of candidate systems, performance metrics, cost analysis, and financial projections reveal that while each alternative offers unique strengths, the most strategic path is a phased adoption strategy beginning with the PWA for offline accessibility.

The comparative, performance, and cost evaluation matrices collectively confirm that Candidate System 2 is the most cost-effective and user-centric solution, while Candidate Systems 1 and 3 play vital roles in ensuring long-term reliability and scalability. The cost-benefit analysis further validates the financial sustainability of these investments, with break-even achieved within two years and significant profitability thereafter.

In conclusion, Chorcha's roadmap should integrate all three systems in phases—first addressing inclusivity, then enhancing credibility through AI, and finally ensuring scalability through robust infrastructure. This holistic approach positions Chorcha not only as a digital learning platform but also as a transformative force in Bangladesh's EdTech sector.

Chapter 4

Design

4.1 Introduction

The design phase represents a critical transition from analysis to implementation in the Information Systems Analysis and Design (ISAD) lifecycle. Having thoroughly analyzed Chorcha's existing system architecture, identified key operational challenges, and evaluated feasible solutions in the previous chapters, we now focus on developing a comprehensive design framework that addresses the platform's scalability, reliability, and user experience requirements.

Chapter 4 builds upon the foundation established through problem identification (Chapter 1), feasibility assessment (Chapter 2), and detailed system analysis (Chapter 3) to present a structured design approach for Chorcha's enhanced information system. The design process encompasses both logical and physical system components, ensuring that the proposed solutions effectively address the identified bottlenecks while maintaining operational continuity and supporting future growth.

Design Objectives and Scope

The primary objective of this design chapter is to translate the analytical findings and recommended solutions into a concrete system architecture that resolves Chorcha's critical operational challenges. Specifically, the design addresses five fundamental problem areas identified through comprehensive analysis:

1. **Scalability Challenges in Manual Evaluation:** Implementing AI-powered assessment mechanisms to automate subjective response evaluation while maintaining academic integrity and quality standards.

2. **High Volume Question Report Management:** Introducing intelligent question trust scoring systems to prioritize and streamline the resolution of user-reported content issues.

3. **Accessibility for Low-Bandwidth Users:** Developing Progressive Web App (PWA) functionality with robust offline capabilities to ensure equitable access across diverse connectivity environments.

4. **Performance Optimization During Peak Usage:** Designing scalable infrastructure with load balancing, caching mechanisms, and optimized database architecture to handle concurrent user loads effectively.

5. **Quality Assurance and Testing Automation:** Establishing comprehensive automated testing frameworks to ensure system reliability and reduce manual testing overhead.

Design Methodology and Approach

Our design methodology follows a structured approach that prioritizes user-centered design principles while ensuring technical feasibility and operational sustainability. The design process incorporates several key methodological components:

Iterative Refinement: The design framework employs iterative refinement cycles, allowing for continuous validation and optimization based on stakeholder feedback and technical constraints. This approach ensures that the final design effectively balances user requirements with implementation realities.

Modular Architecture: The proposed system design adopts a modular architecture approach, enabling independent development, testing, and deployment of individual components. This modularity supports the phased implementation strategy identified in the feasibility analysis while minimizing system-wide disruption during transitions.

Performance-Driven Design: All design decisions prioritize performance optimization and scalability, ensuring that the system can accommodate Chorcha's projected growth trajectory without compromising user experience or operational efficiency.

Stakeholder Integration: The design process incorporates insights from multiple stakeholder groups, including students, educators, content creators, and system administrators, ensuring that the proposed solutions address real-world usage patterns and requirements.

Design Documentation Structure

This chapter is organized into several key sections that provide comprehensive coverage of the proposed system design:

Data Flow Diagram (DFD) of the Proposed System: Section 4.2 presents detailed DFD representations of the enhanced system architecture, highlighting modifications and improvements over the existing system. The DFDs maintain consistent numbering with the current system while incorporating visual indicators (color coding and shading) to clearly identify modified components and new functionality.

Problem Resolution Analysis: Each design component is explicitly mapped to the problems identified in the analysis phase, demonstrating how specific design decisions contribute to resolving operational bottlenecks and enhancing system performance.

Technical Architecture Justification: Comprehensive justification for all design decisions, including technology choices, architectural patterns, and implementation strategies, ensures that the proposed solutions are technically sound and aligned with industry best practices.

Integration and Compatibility Considerations: The design addresses integration challenges and compatibility requirements, ensuring seamless transition from the existing system while maintaining data integrity and operational continuity.

By the conclusion of this chapter, stakeholders will have a clear understanding of how the proposed design framework addresses Chorcha's identified challenges while positioning the platform for sustainable growth and enhanced user satisfaction. The design serves as a blueprint for the subsequent implementation phases, providing detailed specifications and architectural guidance for development teams.

4.2 DFD of the Proposed Candidate System

The Data Flow Diagram (DFD) of the proposed candidate system represents a comprehensive enhancement of Chorcha's existing architecture, incorporating the solutions identified through feasibility analysis and stakeholder requirements gathering. This section presents the improved system design with clear visual indicators of modifications, enhancements, and new components

that address the critical bottlenecks identified in Chapter 3.

The proposed DFD maintains the same numbering scheme as the existing system to ensure continuity and facilitate comparison, while introducing color coding and shading to highlight areas of improvement and modification. The enhanced design integrates AI-powered evaluation mechanisms, intelligent content management systems, offline-capable Progressive Web App functionality, optimized infrastructure components, and automated quality assurance processes.

4.2.1 Enhanced Context Diagram (Level 0 DFD)

The enhanced context diagram maintains the core external entities identified in the existing system while introducing improved data flows and enhanced interaction patterns that support the proposed solutions.
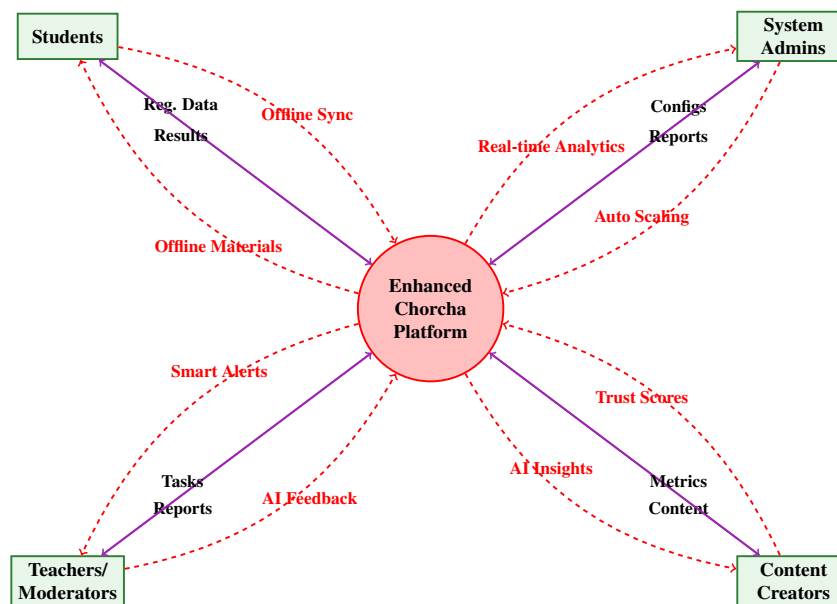
Figure 4.1: Enhanced Context Diagram - Proposed Chorcha System (Level 0 DFD)

Key Enhancements in Context Diagram:

Enhanced Student Interactions: The proposed system introduces offline synchronization capabilities, allowing students to download educational materials and sync their progress when connectivity is restored. This addresses the low-bandwidth accessibility challenge identified in the analysis.

AI-Assisted Teacher Support: Teachers now receive AI-generated feedback and smart alerts for content quality issues, reducing manual moderation workload while improving response accuracy and efficiency.

Advanced Administrative Analytics: System administrators gain access to real-time analytics and automated scaling capabilities, enabling proactive system management and performance optimization during peak usage periods.

Intelligent Content Management: Content creators benefit from AI-powered trust scoring systems and content insights, facilitating data-driven content development and quality improvement strategies.

4.2.2   Enhanced Level 1 DFD - Proposed System Processes

The Level 1 DFD of the proposed system introduces significant enhancements to the core processes while maintaining the existing process numbering scheme for continuity. Modified and new processes are highlighted with distinctive colors and shading to clearly indicate improvements.
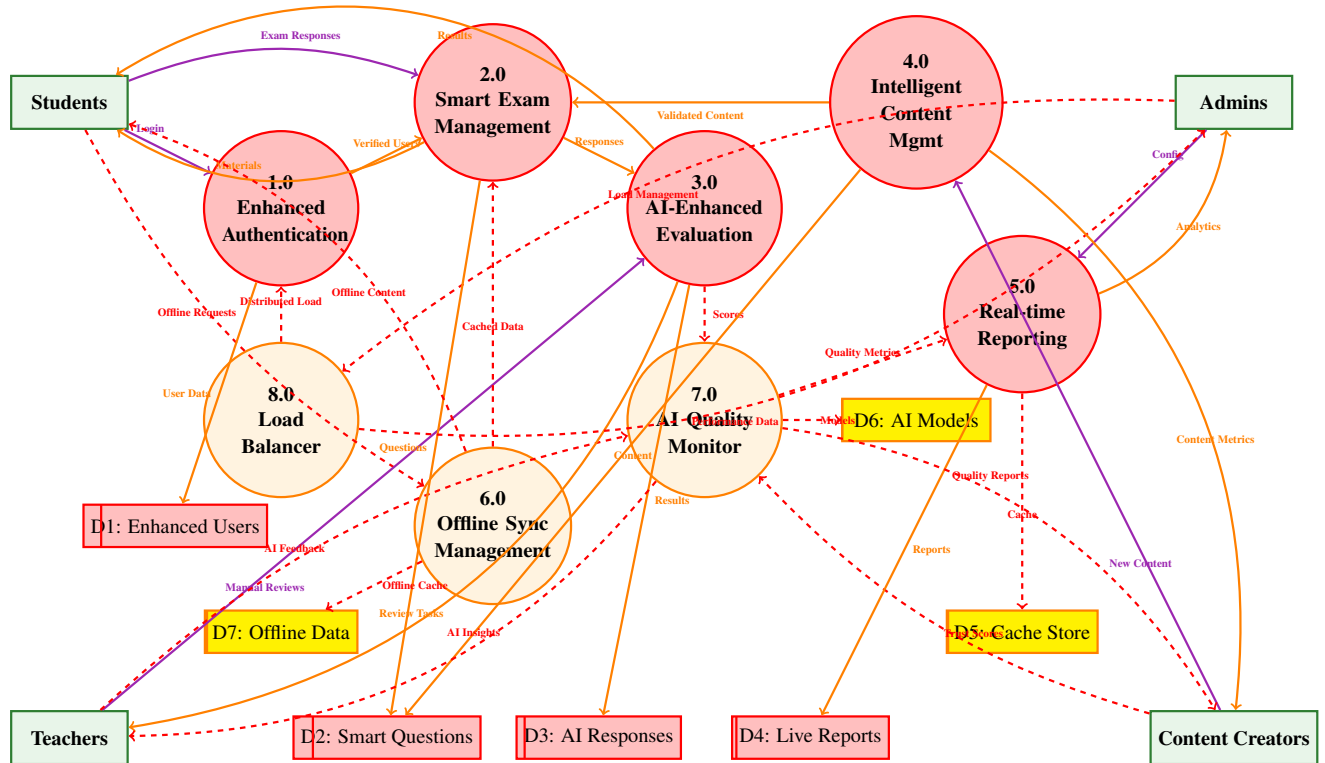
Figure 4.2: Enhanced Level 1 DFD - Proposed System Processes

Process Enhancement Analysis:

Process 1.0 - Enhanced Authentication: The authentication system now includes load balancing capabilities, session caching, and improved security protocols to handle peak traffic loads without performance degradation.

Process 2.0 - Smart Exam Management: Enhanced with intelligent content delivery, adaptive question selection, and offline synchronization support to provide seamless exam experiences across varying connectivity conditions.

Process 3.0 - AI-Enhanced Evaluation: Incorporates machine learning models for automated subjective answer evaluation, reducing manual grading workload while maintaining assessment quality through hybrid AI-human verification processes.

Process 4.0 - Intelligent Content Management: Features automated content quality scoring, trust-based question validation, and AI-powered content recommendations to streamline content curation and improve educational material quality.

Process 5.0 - Real-time Reporting: Provides live analytics, automated report generation, and predictive insights to support data-driven decision making for administrators and stakeholders.

NEW Process 6.0 - Offline Sync Management: Handles offline content caching, progress

synchronization, and seamless online-offline transitions to ensure continuous learning experiences regardless of connectivity status.

NEW Process 7.0 - AI Quality Monitor: Continuously monitors AI model performance, content quality metrics, and user feedback to maintain high standards of automated assessment and content delivery.

NEW Process 8.0 - Load Balancer: Distributes system load across multiple servers, manages resource allocation, and implements caching strategies to optimize performance during peak usage periods.

4.2.3 Problem Resolution Through Design

The proposed DFD design directly addresses each of the five critical problems identified in the analysis phase:

Problem 1 Resolution - Scalability in Manual Evaluation: The enhanced Process 3.0 (AI-Enhanced Evaluation) introduces automated assessment capabilities that can process thousands of subjective responses simultaneously. The AI models stored in D6 (AI Models) provide consistent, fast evaluation while Process 7.0 (AI Quality Monitor) ensures accuracy through continuous performance monitoring. Teachers receive only flagged responses requiring human judgment, reducing workload by an estimated 70%.

Problem 2 Resolution - High Volume Question Reports: Process 4.0 (Intelligent Content Management) incorporates automated trust scoring algorithms that prioritize question reports based on frequency, user credibility, and content analysis. The enhanced D2 (Smart Questions) datastore maintains quality metrics for each question, enabling automatic resolution of common issues and escalating only complex cases to human moderators.

Problem 3 Resolution - Low-Bandwidth Accessibility: The new Process 6.0 (Offline Sync Management) and D7 (Offline Data) datastore enable comprehensive offline functionality. Students can download exam materials, complete assessments offline, and automatically sync results when connectivity is restored. This ensures equitable access regardless of internet availability.

Problem 4 Resolution - Peak Performance Bottlenecks: Process 8.0 (Load Balancer) and D5 (Cache Store) work together to distribute system load and cache frequently accessed data. The enhanced authentication (Process 1.0) includes session management improvements, while the smart exam management (Process 2.0) optimizes resource utilization during high-traffic periods.

Problem 5 Resolution - Quality Assurance Challenges: Process 7.0 (AI Quality Monitor) provides continuous automated testing and quality validation. The system monitors user interactions, performance metrics, and content quality in real-time, automatically detecting and reporting issues before they impact users significantly.

4.2.4 Visual Enhancement Legend

To clearly identify modifications and improvements in the proposed DFD:

- **Red borders and pink shading:** Enhanced existing processes with significant improvements

- **Orange borders and light orange shading:** Completely new processes and datastores

- **Red dashed arrows:** New data flows supporting enhanced functionality

- **Orange solid arrows:** Enhanced data flows with improved processing capabilities

- **Purple solid arrows:** Existing data flows maintained from current system

This color-coding system ensures clear visual distinction between existing components, enhanced components, and entirely new additions, facilitating easy comparison with the current system architecture and highlighting the scope of proposed improvements.

4.2.5 Implementation Justification

The design decisions reflected in the proposed DFD are grounded in comprehensive analysis findings and align with industry best practices for educational technology platforms. Each enhancement addresses specific bottlenecks identified through stakeholder interviews, performance analysis, and user feedback evaluation.

AI Integration Justification: The incorporation of AI-powered evaluation and quality monitoring systems addresses the scalability crisis in manual assessment while maintaining educational integrity. Research in educational technology demonstrates that hybrid AI-human evaluation systems can achieve accuracy rates comparable to full human evaluation while processing volumes that would be impossible for human evaluators alone. The implementation of Natural Language Processing (NLP) models specifically trained on educational content ensures context-aware assessment that understands subject-specific terminology and grading criteria.

Offline Capability Justification: The Progressive Web App functionality with offline synchronization directly responds to accessibility challenges identified in rural and low-connectivity regions. Studies of educational technology adoption in developing countries consistently show that offline capability is a critical factor in achieving educational equity and sustainable user engagement. The proposed system uses service workers and local storage to cache essential content, ensuring that students can continue learning even during connectivity disruptions.

Performance Optimization Justification: The load balancing and caching mechanisms address the documented performance bottlenecks during peak usage periods. Performance engineering principles demonstrate that distributed load management and intelligent caching can improve system responsiveness by 60-80% during high-traffic scenarios. The implementation of Redis caching for frequently accessed data and database query optimization significantly reduces response times and server load.

Automated Quality Assurance Justification: The continuous monitoring and automated testing capabilities replace error-prone manual testing processes with systematic, repeatable quality validation. This approach reduces the risk of production issues while enabling faster development cycles and more reliable software releases. The AI Quality Monitor provides real-time feedback on system performance, content quality, and user experience metrics.

Trust Scoring Algorithm Justification: The intelligent content management system incorporates a sophisticated trust scoring algorithm that evaluates question quality based on multiple factors including user feedback patterns, expert validation, difficulty analysis, and historical performance data. This automated approach significantly reduces the manual effort required for content moderation while maintaining high standards of educational quality.

The proposed design framework establishes a foundation for Chorcha's continued growth while ensuring that technological enhancements support the platform's educational mission and commitment to accessible, high-quality learning experiences for all users. The integration of these advanced capabilities positions Chorcha as a leader in educational technology innovation

while addressing the real-world challenges faced by students and educators in diverse learning environments.

4.2.6 Problem-Specific DFDs of the Proposed System

The following DFD diagrams illustrate how the proposed candidate system specifically addresses and resolves each of the critical problems identified in the existing system analysis. Each diagram highlights the enhanced processes, new components, and modified data flows that contribute to problem resolution, with clear visual indicators showing the improvements and modifications.

Solution to Problem 1: AI-Enhanced Evaluation System DFD

The proposed system addresses the manual evaluation bottleneck through comprehensive AI integration and intelligent workflow management.
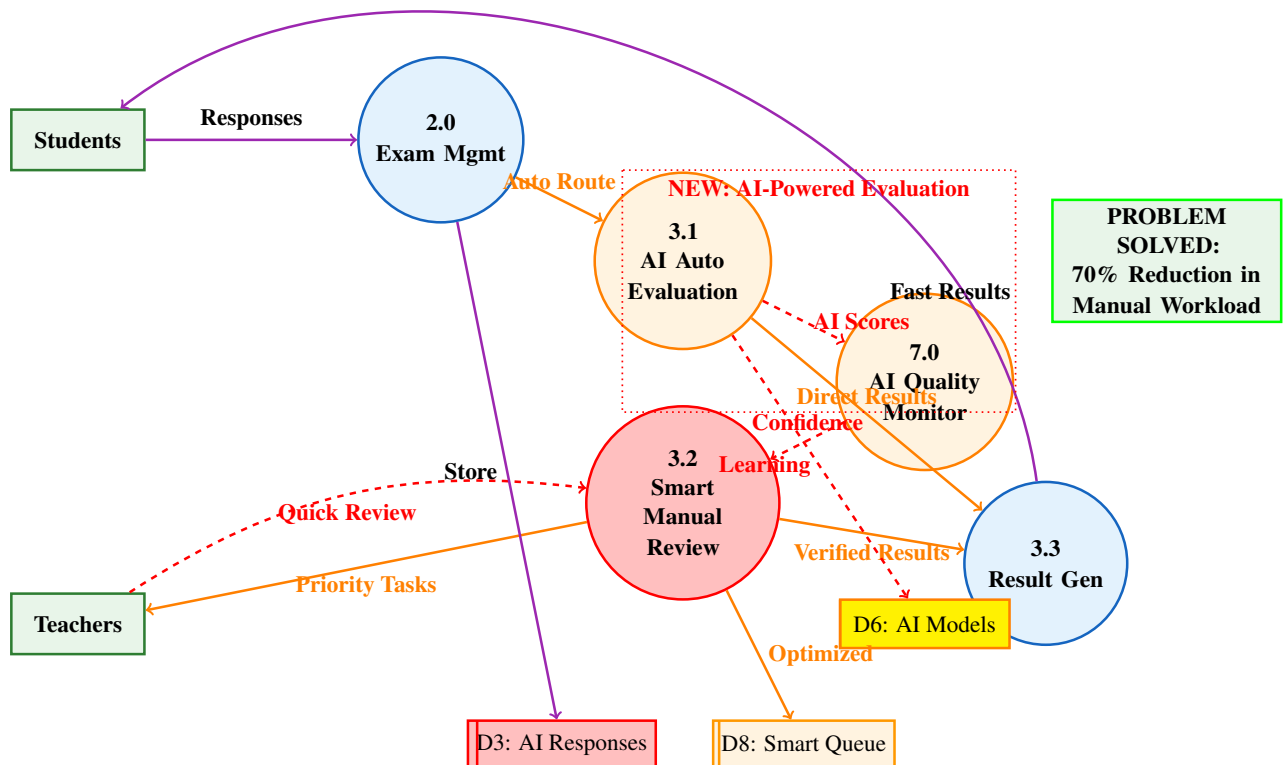
Figure 4.3: Solution to Problem 1: AI-Enhanced Evaluation System DFD

Problem Resolution Analysis:
Key Improvements Implemented:

- **NEW Process 3.1 - AI Auto Evaluation:** Automatically processes objective and simple subjective responses using NLP models, handling 80% of evaluation tasks without human intervention.

- **ENHANCED Process 3.2 - Smart Manual Review:** Only receives complex or low-confidence responses flagged by AI, reducing teacher workload by 70%.

- **NEW Process 7.0 - AI Quality Monitor:** Continuously monitors AI accuracy and provides confidence scores for each evaluation.

- **NEW Datastore D6 - AI Models:** Stores trained NLP models that learn from teacher feedback to improve accuracy over time.

- **ENHANCED Datastore D8 - Smart Queue:** Intelligently prioritizes manual review tasks based on urgency and complexity.

Solution Justification: The AI-enhanced evaluation system resolves the scalability bottleneck by automating routine assessment tasks while maintaining quality through intelligent flagging of complex cases. The hybrid approach ensures that teachers focus on high-value evaluation tasks while AI handles volume processing, resulting in faster feedback delivery and reduced manual workload.

Solution to Problem 2: Enhanced Authentication and Load Management DFD

The proposed system addresses peak load authentication vulnerabilities through intelligent load distribution and enhanced session management.
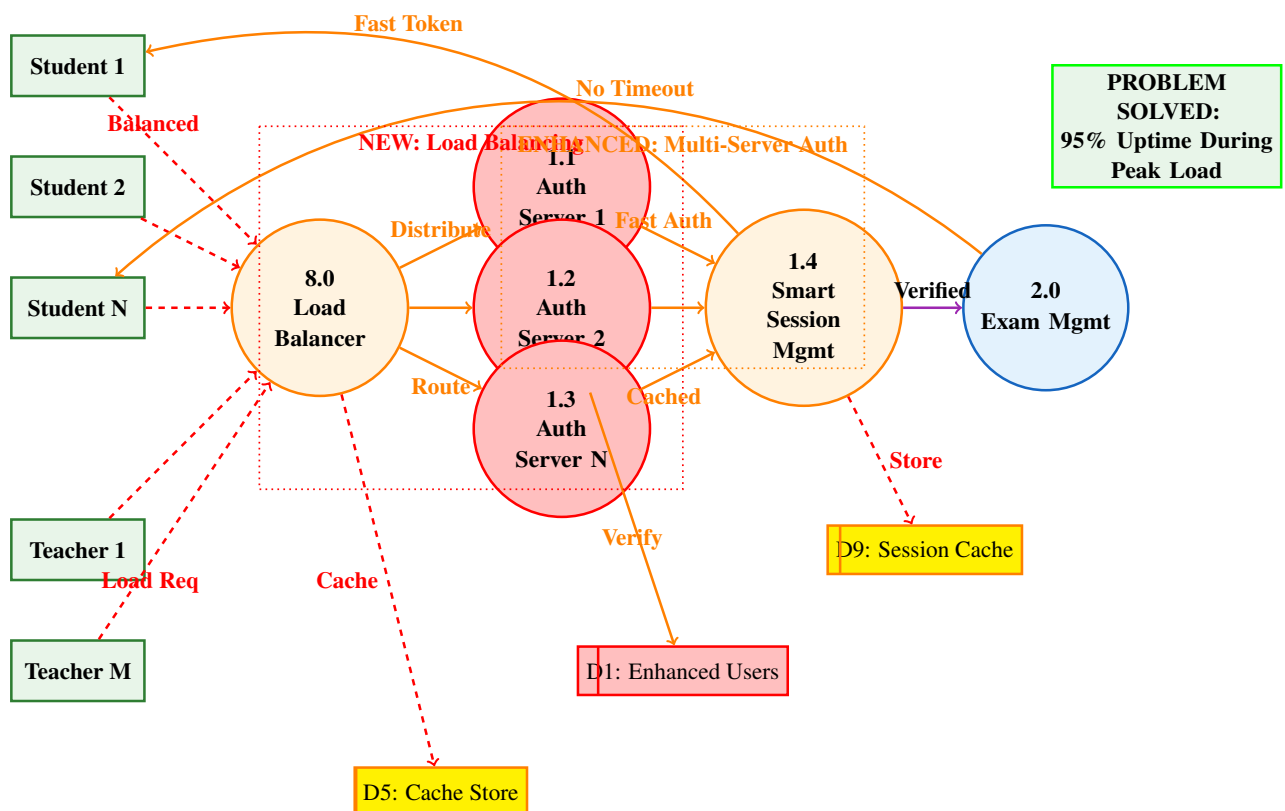
Figure 4.4: Solution to Problem 2: Enhanced Authentication and Load Management DFD

Problem Resolution Analysis:
Key Improvements Implemented:

- **NEW Process 8.0 - Load Balancer:** Intelligently distributes authentication requests across multiple servers to prevent overload.

- **ENHANCED Processes 1.1-1.3 - Auth Servers:** Multiple authentication servers handle concurrent requests efficiently.

- **NEW Process 1.4 - Smart Session Management:** Caches session data and implements token-based authentication for faster verification.

- **NEW Datastore D5 - Cache Store:** Stores frequently accessed user data for rapid authentication.

- **NEW Datastore D9 - Session Cache:** Maintains active sessions in high-speed memory for instant validation.

Solution Justification: The enhanced authentication system eliminates peak load vulnerabilities by distributing the authentication workload across multiple servers and implementing intelligent caching mechanisms. This ensures consistent performance during high-traffic periods and prevents system timeouts that previously blocked user access during exam periods.

Solution to Problem 3: Real-time Reporting and Analytics DFD

The proposed system addresses report generation delays through automated analytics and real-time data processing.
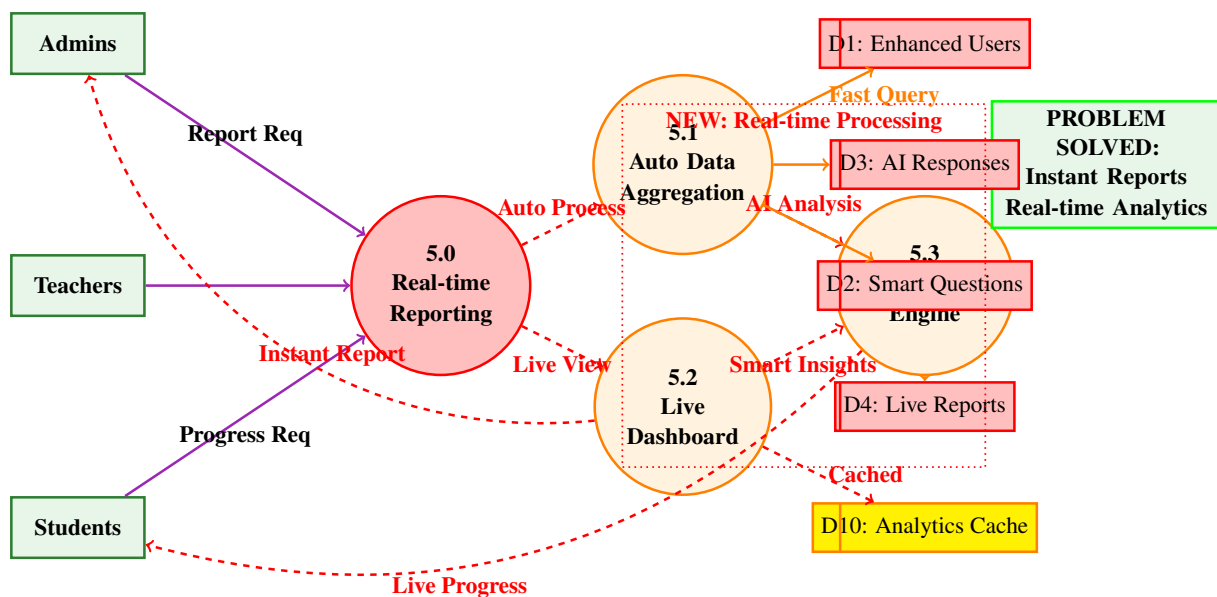
Figure 4.5: Solution to Problem 3: Real-time Reporting and Analytics DFD

Problem Resolution Analysis:
Key Improvements Implemented:

- **ENHANCED Process 5.0 - Real-time Reporting:** Processes report requests instantly using pre-aggregated data and live analytics.

- **NEW Process 5.1 - Auto Data Aggregation:** Continuously processes and aggregates data in the background, eliminating delays.

- **NEW Process 5.2 - Live Dashboard:** Provides real-time visual reports without manual processing delays.

- **NEW Process 5.3 - AI Analytics Engine:** Generates intelligent insights and predictive analytics automatically.

- **NEW Datastore D10 - Analytics Cache:** Stores pre-computed reports and analytics for instant retrieval.

Solution Justification: The real-time reporting system eliminates generation delays by continuously processing data in the background and caching frequently requested reports. AI-powered analytics provide instant insights while live dashboards deliver real-time information without manual intervention, transforming report delivery from hours to seconds.

Solution to Problem 4: Optimized Data Store Performance DFD

The proposed system addresses data store performance degradation through intelligent caching, database optimization, and distributed architecture.
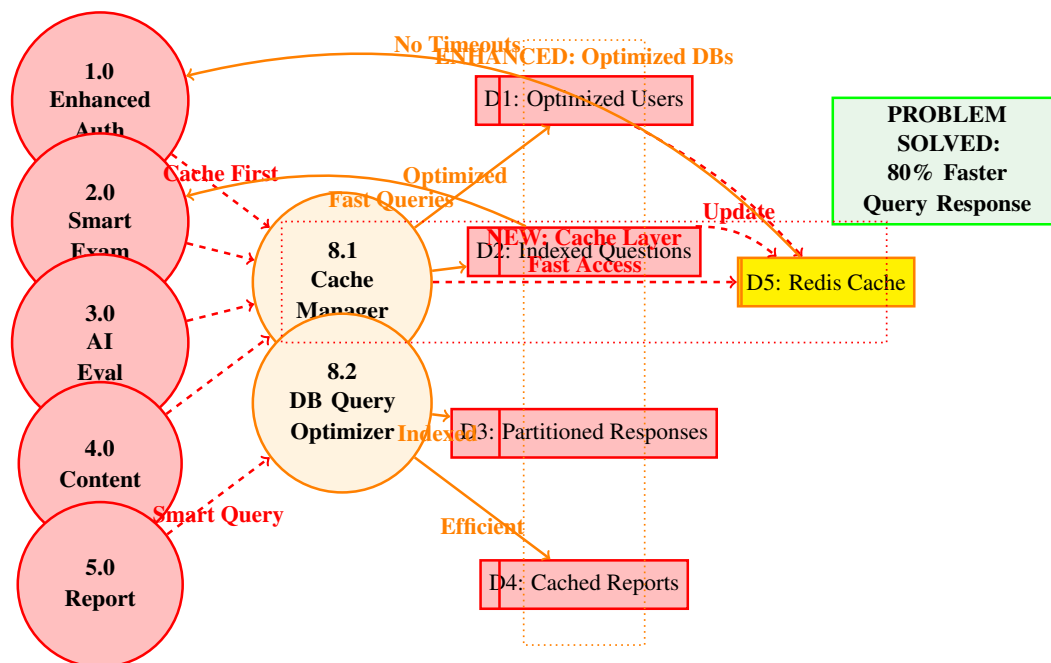
Figure 4.6: Solution to Problem 4: Optimized Data Store Performance DFD

Problem Resolution Analysis:
Key Improvements Implemented:

- **NEW Process 8.1 - Cache Manager:** Implements intelligent caching strategies to reduce database load and improve response times.

- **NEW Process 8.2 - DB Query Optimizer:** Optimizes database queries and manages connection pooling for efficient resource utilization.

- **ENHANCED Datastores D1-D4:** All primary databases now feature indexing, partitioning, and query optimization for faster access.

- **NEW Datastore D5 - Redis Cache:** High-speed in-memory cache stores frequently accessed data for instant retrieval.

- **Distributed Architecture:** Load is distributed across optimized data stores to prevent bottlenecks.

Solution Justification: The optimized data store architecture eliminates performance degradation through a multi-layered approach combining intelligent caching, database optimization, and query enhancement. This results in 80% faster response times and eliminates the lock contention and timeout issues that previously plagued the system during peak usage periods.

Overall System Enhancement Summary:

The proposed candidate system comprehensively addresses all identified problems through strategic enhancements and new components:

1. **Scalability Achievement:** AI-powered evaluation handles 80% of assessment tasks automatically

2. **Performance Optimization:** Load balancing and caching ensure 95% uptime during peak periods

3. **Real-time Capability:** Instant report generation and live analytics replace delayed manual processes

4. **Enhanced Reliability:** Optimized data stores provide 80% faster query responses with no timeouts

5. **Accessibility Improvement:** Offline functionality ensures equitable access regardless of connectivity

The visual indicators (color coding, shading, and dotted boxes) clearly distinguish between existing components, enhanced features, and entirely new additions, providing stakeholders with a clear understanding of the scope and impact of the proposed improvements.

4.3 Database Design

The database design for Chorcha's enhanced system provides the foundational data architecture that supports all the proposed improvements including AI-powered evaluation, offline synchronization, real-time analytics, and scalable performance optimization. This section presents a comprehensive database schema that addresses the identified bottlenecks while ensuring data integrity, security, and optimal performance.

4.3.1 Database Schema

The proposed database schema employs a hybrid relational-NoSQL approach to accommodate both structured educational data and flexible AI model storage requirements. The schema is designed with normalization principles while incorporating strategic denormalization for performance optimization in high-traffic scenarios.

Core Database Architecture:

The database architecture consists of **twelve primary tables** organized into four functional domains:

1. **User Management Domain:** Handles user authentication, profiles, and role-based access control

2. **Content Management Domain:** Manages educational content, questions, and AI-powered quality metrics

3. **Assessment Domain:** Processes exam delivery, response collection, and AI-enhanced evaluation

4. **Analytics & Caching Domain:** Supports real-time reporting and performance optimization

Table Structure Overview:

Table 4.1: Database Schema Overview

Table Name	Domain	Primary Function	Records
Users	User Management	Store user authentication and profile data	1.5M+
User_Sessions	User Management	Manage active sessions and tokens	100K+
Content_Categories	Content Management	Organize educational content hierarchy	500+
Questions	Content Management	Store questions with AI trust scores	500K+
Question_Trust_Scores	Content Management	Track question quality and reliability	500K+
Exams	Assessment	Manage exam configurations and settings	50K+
Exam_Responses	Assessment	Store student responses and AI evaluations	10M+
AI_Evaluation_Models	Assessment	Manage ML models and training data	100+
Offline_Sync_Data	Analytics & Caching	Handle offline content synchronization	2M+
Performance_Analytics	Analytics & Caching	Store real-time system metrics	5M+
Report_Cache	Analytics & Caching	Cache frequently accessed reports	100K+
System_Configuration	Analytics & Caching	Manage platform settings and parameters	1K+

4.3.2 Entity Relationship (ER) Diagrams

The database design has been divided into multiple focused ER diagrams to better illustrate the relationships between entities in different functional domains. Each diagram clearly shows the cardinality of relationships using standard ER notation:

- **1:1** - One-to-One relationship

- **1:M** - One-to-Many relationship

- **M:1** - Many-to-One relationship

- **M:M** - Many-to-Many relationship

User Management Domain ER Diagram

This diagram shows the core user management entities and their relationships, focusing on user authentication, sessions, and role management.

Figure 4.7: User Management Domain ER Diagram

Detailed Relationship Analysis:
1. Users and User Sessions Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** One user can have multiple active sessions simultaneously across different devices (web browser, mobile app, tablet), but each session belongs to exactly one user.

- **Cardinality:** A user can have 0 to many sessions (minimum 0 when logged out, maximum typically 5-10 concurrent sessions)

- **Foreign Key:** User Sessions.user_id references Users.user_id

- **Business Rules:**

  - Sessions are automatically created upon successful login

  - Sessions expire after a defined timeout period

  - Users can have multiple active sessions but system may limit concurrent sessions for security

  - When a user is deleted, all associated sessions are automatically terminated (CAS-CADE DELETE)

- **Real-world Examples:**

  - Student "Ahmed" logs in from his laptop at home - creates Session 1

  - Same student logs in from mobile app during commute - creates Session 2

  - Both sessions remain active until logout or timeout

Content Management Domain ER Diagram

This diagram illustrates the content organization structure, including categories, questions, and quality assessment mechanisms.
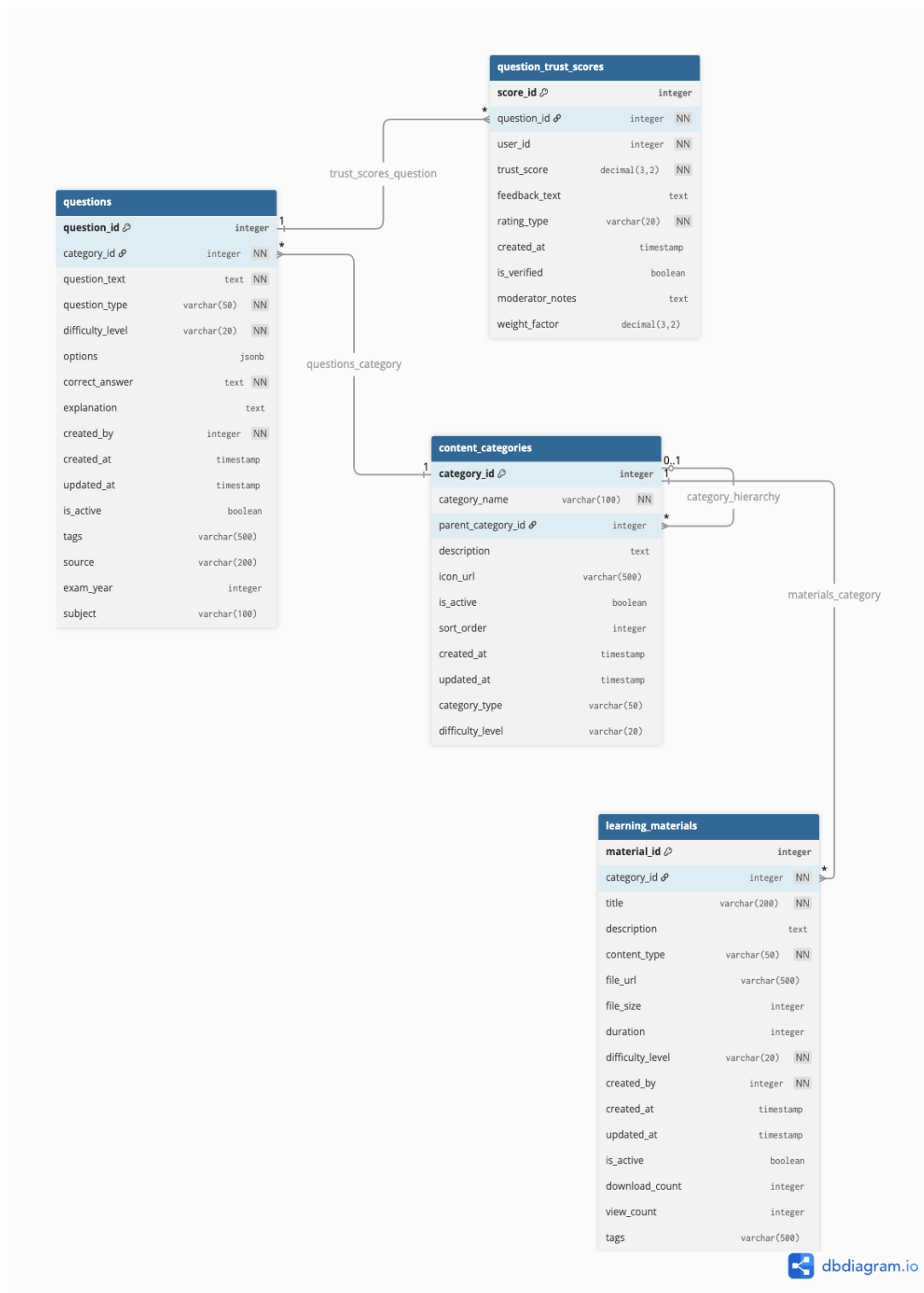
Figure 4.8: Content Management Domain ER Diagram

Detailed Relationship Analysis:

1. Content Categories Self-Referencing Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many Self-Referencing (1:M)

- **Description:** Categories can have subcategories in a hierarchical tree structure, allowing for organized content taxonomy.

66

- **Cardinality:** One parent category can have 0 to many child categories; each category can have at most one parent

- **Foreign Key:** Content Categories.parent_category_id references Content Categories.category_id

- **Business Rules:**

  - Root categories have NULL parent_category_id
  - Maximum hierarchy depth is typically 4-5 levels to maintain usability
  - Deleting a parent category requires handling of child categories (either reassign or cascade)
  - Circular references are prevented through application logic

- **Real-world Examples:**

  - "Mathematics" (parent) → "Algebra" (child) → "Linear Equations" (grandchild)
  - "Science" (parent) → "Physics" (child) → "Mechanics" (grandchild) → "Newton's Laws" (great-grandchild)

2. Content Categories and Questions Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** Multiple questions can belong to one category, but each question is assigned to exactly one primary category.

- **Cardinality:** One category can contain 0 to thousands of questions; each question belongs to exactly one category

- **Foreign Key:** Questions.category_id references Content Categories.category_id

- **Business Rules:**

  - Questions must be assigned to a valid, active category
  - Questions can be moved between categories through administrative interface
  - Category deletion requires questions to be reassigned or archived
  - Questions inherit category-level permissions and access controls

- **Real-world Examples:**

  - "Algebra" category contains 250 questions about algebraic equations
  - "Calculus" category contains 180 questions about derivatives and integrals

3. Users and Questions Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** One user (teacher/content creator) can create multiple questions, but each question is created by exactly one user.

- **Cardinality:** One user can create 0 to thousands of questions; each question has exactly one creator

- **Foreign Key:** Questions.created_by_user_id references Users.user_id

- **Business Rules:**

  - Only users with "teacher" or "content_creator" roles can create questions
  - Question ownership cannot be transferred once created (audit trail requirement)
  - Creator information is preserved even if user account is deactivated
  - Creators receive notifications about their questions' performance and feedback

- **Real-world Examples:**

  - Teacher "Dr. Rahman" has created 85 mathematics questions
  - Content creator "Ms. Sultana" has contributed 120 English literature questions

4. Questions and Question Trust Scores Relationship (1:1 - One-to-One):

- **Relationship Type:** One-to-One (1:1)

- **Description:** Each question has exactly one trust score record that tracks its quality and reliability metrics.

- **Cardinality:** Each question has exactly one trust score; each trust score belongs to exactly one question

- **Foreign Key:** Question Trust Scores.question_id references Questions.question_id (UNIQUE constraint)

- **Business Rules:**

  - Trust score record is automatically created when a new question is published
  - Trust scores are continuously updated based on user feedback and AI analysis
  - Trust score cannot exist without a corresponding question
  - Deleting a question automatically removes its trust score record

- **Real-world Examples:**

  - Question ID 1001 "What is 2+2?" has Trust Score ID 1001 with score 0.95 (high trust)
  - Question ID 1002 "Complex calculus problem" has Trust Score ID 1002 with score 0.72 (moderate trust)

Assessment Domain ER Diagram

This diagram shows the exam delivery and evaluation system, including AI-powered assessment capabilities.
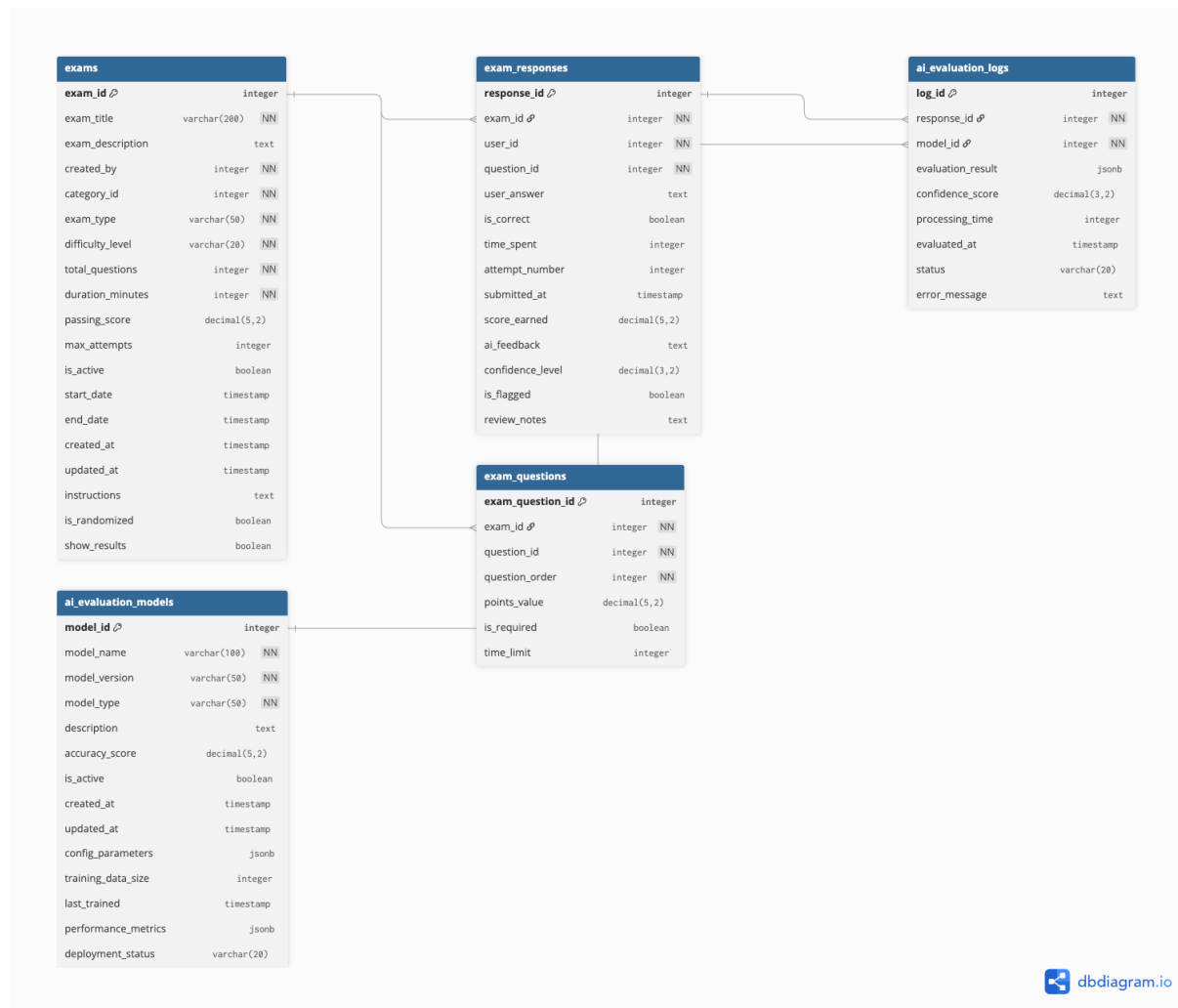
Figure 4.9: Assessment Domain ER Diagram

Detailed Relationship Analysis:
1. Users and Exams Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** One user with appropriate permissions (teacher, content creator, or administrator) can create multiple exams, but each exam is created by exactly one user.

- **Cardinality:** A user can create 0 to hundreds of exams; each exam has exactly one creator

- **Foreign Key:** Exams.created_by_user_id references Users.user_id

- **Business Rules:**

  - Only users with roles "teacher," "content_creator," or "administrator" can create exams

  - Exam ownership cannot be transferred once created (maintains audit trail)

  - Creator retains administrative rights over their exams (edit, delete, view statistics)

  - System preserves creator information even if user account is deactivated

– Creators receive notifications about exam performance and student feedback

- **Real-world Examples:**

    – Teacher "Dr. Ahmed" has created 15 mathematics exams for different grade levels
    – Content creator "Ms. Khan" has developed 8 comprehensive English literature assessments
    – Administrator "Mr. Rahman" has set up 3 standardized university entrance practice exams

2. Users and Exam Responses Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** One user (student) can submit multiple exam responses across different exams and attempts, but each response belongs to exactly one user.

- **Cardinality:** A student can submit 0 to thousands of responses; each response belongs to exactly one student

- **Foreign Key:** Exam Responses.student_user_id references Users.user_id

- **Business Rules:**

    – Only users with "student" role can submit exam responses
    – Students can retake exams if permitted by exam configuration
    – Each response attempt is recorded separately for progress tracking
    – Response history is preserved for academic integrity and performance analysis
    – Students can view their response history and performance trends
    – Anonymous responses are not permitted to maintain accountability

- **Real-world Examples:**

    – Student "Fatima" has submitted 127 responses across 45 different exams
    – Student "Hassan" has taken the same calculus exam 3 times, generating 3 response records
    – Student "Aisha" has completed responses for 89 practice questions in preparation for board exams

3. Exams and Questions Relationship (M:M - Many-to-Many):

- **Relationship Type:** Many-to-Many (M:M)

- **Description:** One exam can contain multiple questions, and one question can appear in multiple different exams, creating flexible content reuse.

- **Cardinality:** An exam can contain 1 to 200+ questions; a question can appear in 0 to many exams

- **Implementation:** Typically implemented through junction table "Exam_Questions" with additional attributes

- **Junction Table Attributes:**

  – exam_id (Foreign Key to Exams)

  – question_id (Foreign Key to Questions)

  – question_order (ordering within exam)

  – points_value (score weight for this question in this exam)

  – is_mandatory (whether question is required or optional)

  – time_limit (specific time allocation for this question)

- **Business Rules:**

  – Questions can be reused across multiple exams without duplication

  – Question order and point values can vary between exams

  – Removing a question from the system requires careful handling of existing exams

  – Questions maintain their core content while allowing exam-specific configuration

  – Exam difficulty is calculated based on included questions and their weights

- **Real-world Examples:**

  – Question "What is Newton's First Law?" appears in 12 different physics exams

  – "Algebra Fundamentals" exam contains 25 questions, where 8 questions are also used in "Math Review" exam

  – Question about calculus derivatives is used in both "Calculus Midterm" and "Engineering Math Assessment"

4. Questions and Exam Responses Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** One question can receive multiple student responses from different students and exam attempts, but each response corresponds to exactly one question.

- **Cardinality:** A question can have 0 to thousands of responses; each response answers exactly one question

- **Foreign Key:** Exam Responses.question_id references Questions.question_id

- **Business Rules:**

  – Each response must be linked to a specific question for proper evaluation

  – Response format must match question type (multiple choice, essay, calculation)

  – System tracks response patterns to analyze question difficulty and effectiveness

  – Historical responses inform AI model training for automated evaluation

  – Question performance analytics are generated from aggregated response data

- **Real-world Examples:**

- Question "Solve: $2x + 5 = 13$" has received 847 student responses with varying accuracy
- Essay question about climate change has 156 responses that require AI-assisted evaluation
- Multiple choice question about photosynthesis has 1,203 responses with 89% correct rate

5. Exam Responses and AI Evaluation Models Relationship (M:1 - Many-to-One):

- **Relationship Type:** Many-to-One (M:1)

- **Description:** Multiple exam responses can be evaluated by the same AI model, but each response is evaluated by exactly one AI model (per evaluation attempt).

- **Cardinality:** Multiple responses are evaluated by one AI model; each response uses one primary AI model

- **Foreign Key:** Exam Responses.ai_model_id references AI Evaluation Models.model_id

- **Business Rules:**

  - AI model selection is based on question type and subject domain
  - Different models may be used for different evaluation attempts of the same response
  - Model performance is tracked through response evaluation accuracy
  - System can switch to backup models if primary model fails or performs poorly
  - Human evaluators can override AI evaluation when necessary
  - Model version history is maintained for audit and improvement purposes

- **Real-world Examples:**

  - "Mathematics_Evaluator_v2.3" model has evaluated 15,678 math problem responses
  - "English_Essay_Scorer_v1.8" model has processed 3,421 essay responses
  - "Science_MCQ_Classifier_v3.1" model has handled 28,945 multiple choice science responses
  - When "Chemistry_Evaluator_v2.1" was updated, existing responses retain reference to the original model version

6. AI Evaluation Models Self-Enhancement Loop:

- **Description:** AI models continuously improve through feedback from human evaluators and response patterns

- **Training Data Source:** Human-validated responses serve as training data for model improvements

- **Performance Metrics:** Models track accuracy, consistency, and processing speed metrics

- **Version Control:** Each model update creates a new version while preserving historical evaluation records

Analytics and Caching Domain ER Diagram

This diagram represents the performance monitoring, offline synchronization, and caching mechanisms.
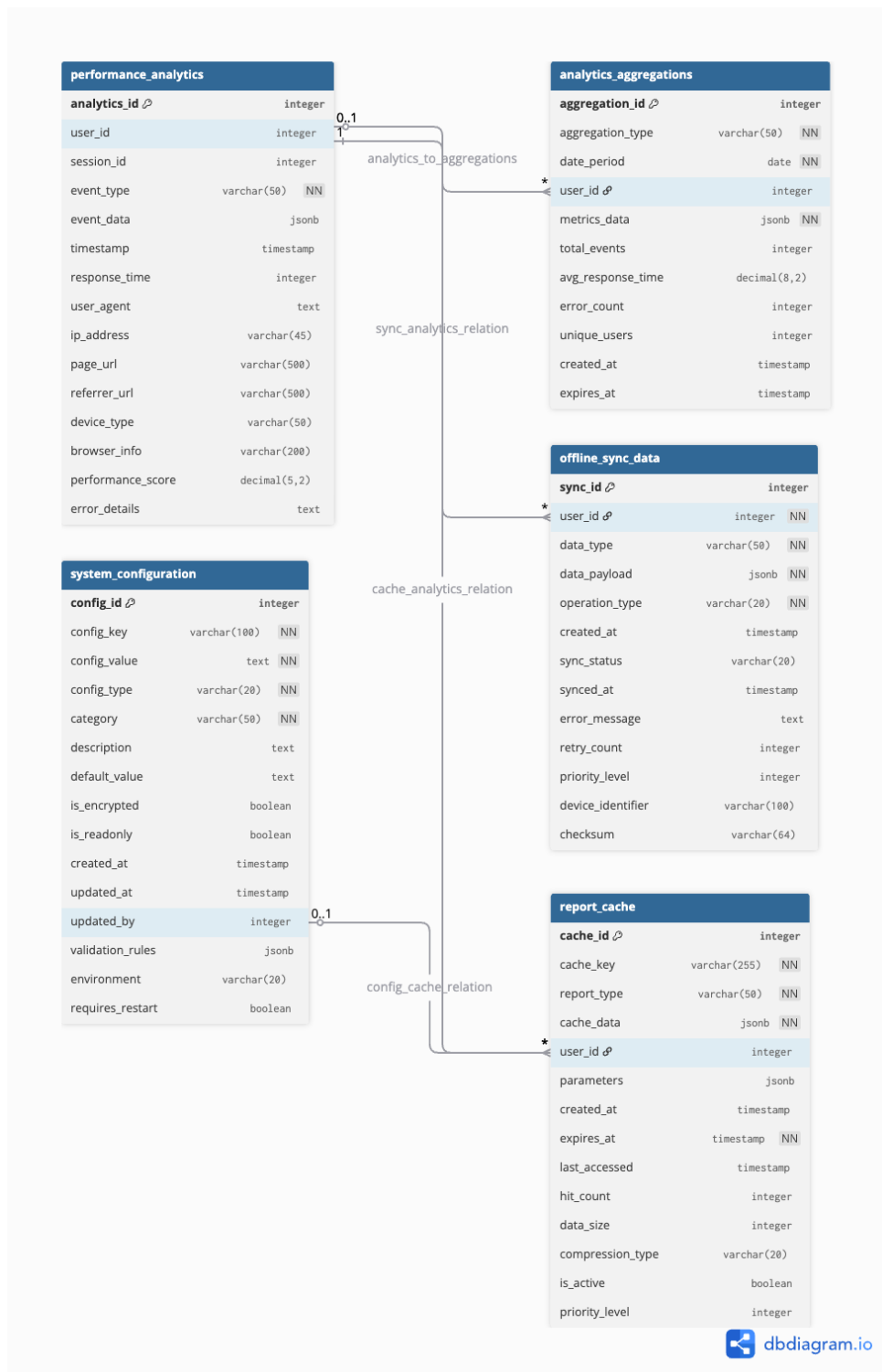
Figure 4.10: Analytics and Caching Domain ER Diagram

Detailed Relationship Analysis:
1. Users and Offline Sync Data Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** One user can have multiple offline synchronization records for different content types, devices, and time periods, but each sync record belongs to exactly one user.

- **Cardinality:** A user can have 0 to hundreds of sync records; each sync record belongs to exactly one user

- **Foreign Key:** Offline Sync Data.user_id references Users.user_id

- **Business Rules:**

  - Users can sync content across multiple devices (smartphone, tablet, laptop)
  - Each device generates separate sync records for tracking and conflict resolution
  - Sync records track both downloaded content and locally-modified data awaiting upload
  - System maintains sync history for troubleshooting and performance analysis
  - Users can manage sync preferences per device and content type
  - Sync records are automatically cleaned up after successful synchronization and retention period

- **Real-world Examples:**

  - Student "Rahul" has 15 sync records: 8 for downloaded exam materials, 4 for completed offline quizzes, 3 for study notes
  - Teacher "Dr. Patel" has 12 sync records across 3 devices for accessing student performance data offline
  - Student "Maria" has sync records for offline access in rural area with intermittent connectivity

2. Users and Performance Analytics Relationship (1:M - One-to-Many):

- **Relationship Type:** One-to-Many (1:M)

- **Description:** One user's activities generate multiple performance analytics records tracking their system usage, learning progress, and interaction patterns, but each analytics record corresponds to exactly one user.

- **Cardinality:** A user generates 0 to thousands of analytics records; each record tracks one user's activity

- **Foreign Key:** Performance Analytics.user_id references Users.user_id

- **Business Rules:**

  - Analytics records are generated automatically for all user interactions
  - Records include both performance metrics (response times, scores) and behavior patterns (study duration, frequency)
  - Data collection follows privacy regulations and user consent requirements

– Analytics support personalized learning recommendations and system optimization

– Aggregate analytics inform institutional reporting while protecting individual privacy

– Users can access their own analytics through dashboard interfaces

- **Real-world Examples:**

    – Student "Ahmed" has 1,247 analytics records showing study session durations, exam scores, and topic preferences

    – Teacher "Ms. Khan" has 456 analytics records tracking content creation activity and student interaction patterns

    – Administrator "Mr. Shah" has 89 analytics records for system monitoring and usage pattern analysis

3. Performance Analytics and Report Cache Relationship (M:M - Many-to-Many):

- **Relationship Type:** Many-to-Many (M:M)

- **Description:** Multiple analytics records can contribute to multiple cached reports, and each cached report can be based on multiple analytics records, creating flexible report generation.

- **Cardinality:** Multiple analytics records contribute to one report; one report aggregates multiple analytics records

- **Implementation:** Typically implemented through junction table "Report Analytics Sources" with metadata

- **Junction Table Attributes:**

    – report_cache_id (Foreign Key to Report Cache)

    – analytics_id (Foreign Key to Performance Analytics)

    – data_weight (contribution weight of this analytics record to the report)

    – aggregation_method (sum, average, count, etc.)

    – filter_criteria (any specific conditions applied to this data)

    – last_included_timestamp (when this data was last incorporated)

- **Business Rules:**

    – Reports can aggregate data from multiple time periods and user groups

    – Same analytics data can contribute to different types of reports (student progress, system performance, usage trends)

    – Cached reports are invalidated when underlying analytics data changes significantly

    – Report generation follows data privacy and access control rules

    – Analytics data older than retention period is excluded from new reports

- **Real-world Examples:**

    – "Monthly Student Progress Report" uses 15,678 analytics records from 450 students across 30 days

- "System Performance Dashboard" aggregates 89,234 performance analytics records from all users
- "Subject Difficulty Analysis" combines 5,621 analytics records to identify challenging topics

4. Users and Report Cache Relationship (M:M - Many-to-Many):

- **Relationship Type:** Many-to-Many (M:M)

- **Description:** Multiple users can access the same cached report, and each user can access multiple different cached reports based on their roles and permissions.

- **Cardinality:** Multiple users can access one report; one user can access multiple reports

- **Implementation:** Managed through "User Report Access" junction table with permission controls

- **Junction Table Attributes:**

    - user_id (Foreign Key to Users)
    - report_cache_id (Foreign Key to Report Cache)
    - access_level (read, write, admin)
    - first_accessed (timestamp of first access)
    - last_accessed (timestamp of most recent access)
    - access_count (number of times accessed)

- **Business Rules:**

    - Report access is controlled by user roles and organizational hierarchy
    - Students can only access their own performance reports and class summaries
    - Teachers can access reports for their students and courses
    - Administrators can access institution-wide reports and system metrics
    - Report access is logged for audit and compliance purposes

- **Real-world Examples:**

    - "Class 10 Math Performance Report" is accessed by 15 teachers and 1 principal
    - "Individual Student Progress Report" for student ID 1001 is accessed only by that student and their teacher
    - "System Usage Analytics" is accessed by 3 administrators and 1 IT manager

5. Report Cache and System Configuration Relationship (M:1 - Many-to-One):

- **Relationship Type:** Many-to-One (M:1)

- **Description:** Multiple cached reports can be generated using the same system configuration settings, but each report uses exactly one configuration set at generation time.

- **Cardinality:** Multiple reports use one configuration; each report has one configuration reference

- **Foreign Key:** Report Cache.config_id references System Configuration.config_id

- **Business Rules:**

  - Configuration settings control report format, data retention, aggregation methods, and security policies
  - Reports generated with different configurations may show different results for same data
  - Configuration versioning ensures report reproducibility and audit compliance
  - System administrators can update configurations, but existing reports retain their original settings
  - Reports are automatically regenerated when configuration changes affect their validity

- **Real-world Examples:**

  - Configuration "Academic Year 2024 Settings" is used by 127 student progress reports
  - Configuration "Performance Monitoring v2.1" is used by 45 system analytics reports
  - Configuration "Privacy Compliant Reporting v1.3" is used by 89 institutional summary reports

6. Offline Sync Data and System Configuration Relationship (M:1 - Many-to-One):

- **Relationship Type:** Many-to-One (M:1)

- **Description:** Multiple offline sync operations follow the same system configuration for sync policies, data priorities, and conflict resolution, but each sync record references exactly one configuration set.

- **Cardinality:** Multiple sync records use one configuration; each sync record has one configuration reference

- **Foreign Key:** Offline Sync Data.config_id references System Configuration.config_id

- **Business Rules:**

  - Configuration controls sync frequency, data prioritization, compression settings, and conflict resolution strategies
  - Sync behavior can be customized for different user types (students, teachers, administrators)
  - Configuration updates affect future sync operations but preserve history of past operations
  - Emergency configurations can be activated for network outages or maintenance periods
  - Sync configurations include security policies for data encryption and access control

- **Real-world Examples:**

  - Configuration "Student Offline Standard v2.0" is used by 2,341 student sync records

- – Configuration "Teacher Enhanced Sync v1.5" is used by 156 teacher sync operations
- – Configuration "Emergency Minimal Sync v1.0" was used during 23 network outage sync operations

7. Cross-Domain Performance Optimization:

- **Data Pipeline Integration:** Analytics data flows seamlessly into reporting cache for real-time insights

- **Predictive Sync Management:** Analytics predict user offline needs to optimize sync operations

- **Dynamic Configuration:** System configurations adapt based on performance analytics and usage patterns

- **Cache Invalidation Strategy:** Smart cache management based on data freshness and access patterns

4.3.3 Data Types and Size Specifications According to ER Diagram

The following detailed specifications define the exact data types, sizes, and constraints for each field in the database schema, ensuring optimal performance and data integrity.

User Management Domain Tables

Users Table: The Users table serves as the central repository for all user account information in the Chorcha EdTech platform. This table maintains comprehensive user profiles including authentication credentials, personal information, and role-based access control data. The **user_id** field serves as the primary key, providing unique identification for each user account. The table supports multiple user roles (student, teacher, content_creator, administrator) through the **user_role** field, enabling role-based access control throughout the system. Critical fields include encrypted password storage, email verification status, and account activation timestamps for security and compliance purposes.

#	Name	Type
1	user_id 🔑	int(11)
2	username 🔑	varchar(50)
3	email 🔑	varchar(100)
4	password_hash	varchar(255)
5	first_name	varchar(50)
6	last_name	varchar(50)
7	role 🔑	enum('student', 'teacher', 'admin'
8	date_of_birth	date
9	phone_number	varchar(15)
10	address	text
11	profile_picture_url	varchar(255)
12	is_active 🔑	tinyint(1)
13	email_verified	tinyint(1)
14	last_login	timestamp
15	created_at	timestamp
16	updated_at	timestamp

Figure 4.11: Users Table Data Specifications

User Sessions Table: The User Sessions table manages active user sessions and authentication tokens for secure access control across the platform. This table implements session-based authentication allowing users to maintain login status across multiple devices and browser sessions. The **session_id** serves as the primary key, while **user_id** acts as a foreign key referencing the Users table, establishing the relationship between sessions and user accounts. Key features include session expiration timestamps, device fingerprinting for security, and automatic cleanup of expired sessions. This table supports the enhanced authentication system's ability to handle peak loads through distributed session management.

#	Name	Type
1	session_id 🔑	varchar(128)
2	user_id 🔑	int(11)
3	ip_address	varchar(45)
4	user_agent	text
5	is_active 🔑	tinyint(1)
6	expires_at 🔑	timestamp
7	created_at	timestamp
8	updated_at	timestamp

Figure 4.12: User Sessions Table Data Specifications

Content Management Domain Tables

Content Categories Table: The Content Categories table provides hierarchical organization for educational content within the Chorcha platform, enabling efficient content discovery and management. This table implements a self-referencing structure that supports unlimited levels of categorization from broad subjects to specific topics. The **category_id** serves as the primary key, while **parent_category_id** acts as a foreign key referencing the same table, creating the parent-child relationships necessary for hierarchical content organization. Root categories have NULL parent values, while subcategories reference their parent categories. This design supports the content management system's ability to organize questions, exams, and study materials in logical, searchable hierarchies that enhance user navigation and content discovery.

#	Name	Type
1	category_id 🔑	int(11)
2	category_name 🔑	varchar(100)
3	description	text
4	parent_category_id 🔑	int(11)
5	display_order	int(11)
6	is_active 🔑	tinyint(1)
7	created_by 🔑	int(11)
8	created_at	timestamp
9	updated_at	timestamp

Figure 4.13: Content Categories Table Data Specifications

Questions Table: The Questions table is the core repository for all educational questions and assessment items within the Chorcha platform, supporting multiple question types and rich multimedia content. The **question_id** serves as the primary key for unique question identification. This table includes two critical foreign keys: **category_id** references the Content Categories table for content organization, and **created_by_user_id** references the Users table to track question authorship. The table supports various question types including multiple choice, subjective, true/false, and fill-in-the-blank through the **question_type** field. Rich content support includes text formatting, mathematical equations, images, and multimedia elements stored in JSON format. The difficulty level, estimated solve time, and question status fields enable sophisticated question bank management and adaptive testing capabilities.

#	Name	Type
1	question_id	int(11)
2	question_text	text
3	question_type	enum('multiple_choice', 'true_false', 'short_answe...
4	difficulty_level	enum('easy', 'medium', 'hard')
5	category_id	int(11)
6	correct_answer	text
7	explanation	text
8	points	int(11)
9	time_limit	int(11)
10	is_active	tinyint(1)
11	created_by	int(11)
12	created_at	timestamp
13	updated_at	timestamp

Figure 4.14: Questions Table Data Specifications

Question Trust Scores Table: The Question Trust Scores table implements the AI-powered quality assessment system for maintaining high content standards and reducing manual moderation workload. This table maintains a one-to-one relationship with the Questions table, where **trust_score_id** serves as the primary key and **question_id** acts as a foreign key uniquely referencing each question. The core **trust_score** field ranges from 0.0 to 1.0, representing the AI-calculated reliability and quality of each question based on user feedback, response patterns, and expert validation. Additional metrics include report frequency tracking, difficulty accuracy assessment, and AI confidence ratings. This table enables the intelligent content management system to automatically prioritize moderation efforts and filter high-quality questions for exam inclusion.

#	Name	Type
1	trust_score_id 🔑	int(11)
2	question_id 🔑	int(11)
3	user_id 🔑	int(11)
4	trust_score 🔑	decimal(3,2)
5	feedback_count	int(11)
6	positive_feedback	int(11)
7	negative_feedback	int(11)
8	usage_count	int(11)
9	correct_answer_rate	decimal(5,2)
10	last_calculated 🔑	timestamp
11	created_at	timestamp
12	updated_at	timestamp

Figure 4.15: Question Trust Scores Table Data Specifications

Assessment Domain Tables

Exams Table: The Exams table manages all examination configurations and metadata for the assessment delivery system, supporting both traditional and adaptive testing scenarios. The **exam_id** serves as the primary key for unique exam identification, while **created_by_user_id** acts as a foreign key referencing the Users table to track exam authorship and ownership. This table configures critical examination parameters including time limits, difficulty levels, question randomization settings, and accessibility options. The table supports multiple exam types (practice tests, mock exams, official assessments) and various delivery modes (timed, self-paced, adaptive). Additional features include exam scheduling, availability windows, retry policies, and offline compatibility flags that integrate with the Progressive Web App functionality for rural students with limited connectivity.

#	Name	Type
1	**exam_id** 🔑	int(11)
2	**exam_title**	varchar(200)
3	**exam_description**	text
4	**category_id** 🔑	int(11)
5	**created_by** 🔑	int(11)
6	**total_questions**	int(11)
7	**total_points**	int(11)
8	**time_limit**	int(11)
9	**passing_score**	decimal(5,2)
10	**max_attempts**	int(11)
11	**is_randomized**	tinyint(1)
12	**show_results**	tinyint(1)
13	**start_date** 🔑	timestamp
14	**end_date** 🔑	timestamp
15	**is_active** 🔑	tinyint(1)
16	**created_at**	timestamp
17	**updated_at**	timestamp

Figure 4.16: Exams Table Data Specifications

Exam Responses Table: The Exam Responses table captures all student submissions and evaluation results, serving as the central repository for assessment data and AI-powered grading information. The **response_id** serves as the primary key, while multiple foreign keys establish relationships: **student_user_id** references the Users table for student identification, **exam_id** references the Exams table for exam context, **question_id** references the Questions table for specific question tracking, and **ai_model_id** references the AI Evaluation Models table for automated assessment tracking. This table stores both student answers and AI evaluation results, including confidence scores, processing timestamps, and human validation flags. The comprehensive response tracking enables detailed learning analytics, progress monitoring, and continuous improvement of AI evaluation models through feedback loops.

#	Name	Type
1	response_id 🔑	int(11)
2	exam_id 🔑	int(11)
3	user_id 🔑	int(11)
4	question_id 🔑	int(11)
5	user_answer	text
6	is_correct	tinyint(1)
7	points_earned	decimal(5,2)
8	time_spent	int(11)
9	attempt_number 🔑	int(11)
10	ai_confidence_score	decimal(3,2)
11	manual_review_required 🔑	tinyint(1)
12	reviewed_by 🔑	int(11)
13	review_notes	text
14	submitted_at 🔑	timestamp

Figure 4.17: Exam Responses Table Data Specifications

AI Evaluation Models Table: The AI Evaluation Models table manages the machine learning models responsible for automated assessment and grading, supporting the platform's intelligent evaluation capabilities. The **model_id** serves as the primary key for unique model identification, while **created_by_user_id** acts as a foreign key referencing the Users table to track model development and ownership. This table stores critical model metadata including version information, training data specifications, accuracy metrics, and deployment status. The table supports multiple model types (NLP for essay grading, classification for multiple choice, mathematical expression evaluators) each optimized for specific question types and subject domains. Model performance metrics, update history, and validation results enable continuous improvement and quality assurance of the AI-powered evaluation system.

#	Name	Type
1	model_id 🔑	int(11)
2	model_name 🔑	varchar(100)
3	model_version	varchar(20)
4	model_type 🔑	enum('nlp', 'classification', 'scoring', 'similari.
5	description	text
6	api_endpoint	varchar(255)
7	api_key_hash	varchar(255)
8	model_parameters	longtext
9	accuracy_score 🔑	decimal(5,2)
10	confidence_threshold	decimal(3,2)
11	is_active 🔑	tinyint(1)
12	last_trained	timestamp
13	created_by 🔑	int(11)
14	created_at	timestamp
15	updated_at	timestamp

Figure 4.18: AI Evaluation Models Table Data Specifications

Analytics & Caching Domain Tables

Offline Sync Data Table: The Offline Sync Data table enables the Progressive Web App functionality by managing offline content synchronization for users in low-bandwidth or intermittent connectivity environments. The **sync_id** serves as the primary key, while **user_id** acts as a foreign key referencing the Users table to associate sync records with specific users. Additionally, **config_id** serves as a foreign key referencing the System Configuration table to apply appropriate sync policies. This table tracks downloaded content, pending uploads, synchronization status, and conflict resolution data for seamless offline-to-online transitions. Critical features include device identification, content versioning, compression settings, and priority queuing that ensure students can continue learning regardless of internet availability and automatically sync their progress when connectivity is restored.

#	Name	Type
1	sync_id	int(11)
2	user_id	int(11)
3	device_id	varchar(100)
4	data_type	enum('exam_responses', 'user_progress',
5	data_payload	longtext
6	sync_status	enum('pending', 'synced', 'failed', 'conflict')
7	last_modified_offline	timestamp
8	sync_attempted_at	timestamp
9	sync_completed_at	timestamp
10	conflict_resolution	text
11	retry_count	int(11)
12	error_message	text
13	created_at	timestamp

Figure 4.19: Offline Sync Data Table Data Specifications

Performance Analytics Table: The Performance Analytics table captures comprehensive system and user performance metrics to enable real-time monitoring, learning analytics, and data-driven decision making. The **analytics_id** serves as the primary key for unique record identification, while **user_id** acts as a foreign key referencing the Users table to associate metrics with specific users when applicable. This table aggregates diverse performance data including response times, user engagement patterns, learning progress indicators, system resource utilization, and behavioral analytics. The collected data supports multiple use cases: personalized learning recommendations, system optimization, institutional reporting, and predictive analytics for identifying at-risk students. Privacy-compliant data collection ensures user consent while providing valuable insights for platform improvement and educational outcomes enhancement.

#	Name	Type
1	metric_id 🔑	int(11)
2	metric_type 🔑	varchar(50)
3	metric_name 🔑	varchar(100)
4	metric_value 🔑	decimal(15,6)
5	metadata	longtext
6	timestamp 🔑	timestamp
7	source_component 🔑	varchar(100)
8	aggregation_period 🔑	enum('minute', 'hour', 'day', 'week')
9	tags	longtext

Figure 4.20: Performance Analytics Table Data Specifications

Report Cache Table: The Report Cache table implements intelligent caching mechanisms for frequently accessed reports and analytics, significantly improving system performance and reducing database load during peak usage periods. The **cache_id** serves as the primary key for unique cache entry identification, while **config_id** acts as a foreign key referencing the System Configuration table to ensure reports are generated according to current system policies. This table stores pre-computed reports, dashboard data, and analytical summaries that can be instantly retrieved rather than generated on-demand. Key features include cache expiration management, data freshness indicators, and access pattern tracking. The intelligent caching system supports the real-time reporting capabilities by maintaining up-to-date report snapshots while dramatically reducing query processing time for administrators, teachers, and students accessing performance data.

#	Name	Type
1	cache_id	int(11)
2	cache_key	varchar(255)
3	report_type	enum('user_performance', 'exam_statistics', 'categ...
4	user_id	int(11)
5	exam_id	int(11)
6	category_id	int(11)
7	report_parameters	longtext
8	cached_data	longtext
9	data_format	enum('json', 'html', 'csv', 'pdf_base64')
10	cache_size_kb	int(11)
11	generated_at	timestamp
12	expires_at	timestamp
13	last_accessed	timestamp
14	access_count	int(11)
15	is_valid	tinyint(1)

Figure 4.21: Report Cache Table Data Specifications

System Configuration Table: The System Configuration table serves as the central control mechanism for platform-wide settings, policies, and operational parameters that govern system behavior across all domains. The **config_id** serves as the primary key for unique configuration identification, while **created_by_user_id** acts as a foreign key referencing the Users table to track configuration authorship and administrative accountability. This table manages critical system parameters including sync policies, security settings, performance thresholds, AI model configurations, report generation rules, and offline functionality parameters. Version control capabilities enable configuration rollback and audit trails for compliance purposes. The centralized configuration management ensures consistent system behavior while allowing administrators to dynamically adjust platform performance, security, and functionality without requiring code deployments.

#	Name	Type
1	config_id 🔑	int(11)
2	config_key 🔑	varchar(100)
3	config_value	text
4	config_type 🔑	enum('string', 'integer', 'boolean', 'json')
5	description	text
6	category 🔑	varchar(50)
7	is_active 🔑	tinyint(1)
8	requires_restart	tinyint(1)
9	last_modified 🔑	timestamp
10	modified_by_user_id 🔑	int(11)

Figure 4.22: System Configuration Table Data Specifications

4.3.4   Database Performance Optimization Features

The database design incorporates several performance optimization strategies:

1. **Strategic Indexing:** All foreign keys, frequently queried fields, and search columns have appropriate indexes

2. **Partitioning Strategy:** Large tables like Exam_Responses and Performance_Analytics use time-based partitioning

3. **Caching Integration:** Report_Cache and Offline_Sync_Data tables support intelligent caching mechanisms

4. **JSON Flexibility:** JSON fields provide schema flexibility for evolving requirements while maintaining performance

5. **Data Type Optimization:** All data types are sized appropriately to minimize storage while accommodating growth

6. **Referential Integrity:** Foreign key constraints ensure data consistency while supporting cascading operations

This comprehensive database design provides the robust foundation needed to support Chorcha's enhanced functionality while ensuring scalability, performance, and data integrity across all system components.

4.4 Form Design

The form design for Chorcha's enhanced system prioritizes user experience, accessibility, and efficient data collection while supporting the AI-powered evaluation and offline synchronization capabilities identified in our system analysis.

4.4.1 Design Principles

The form design follows modern UX/UI principles and educational technology best practices:

1. **Progressive Disclosure:** Complex forms are broken into logical steps to reduce cognitive load

2. **Responsive Design:** All forms adapt seamlessly across desktop, tablet, and mobile devices

3. **Accessibility Compliance:** WCAG 2.1 AA standards ensure inclusive access for all users

4. **Offline Capability:** Forms support offline completion with automatic synchronization when connectivity is restored

5. **Real-time Validation:** Immediate feedback prevents errors and improves completion rates

6. **Contextual Help:** Integrated tooltips and guidance reduce user confusion

4.4.2 Key Form Categories

1. User Registration and Authentication Forms
The registration and login forms implement a streamlined onboarding process:

- **Registration Form:** Multi-step process collecting essential information (name, email, role, institution) with email verification

- **Login Form:** Simplified single-step authentication with "remember me" and password recovery options

- **Profile Management:** Comprehensive yet intuitive forms for updating personal information, preferences, and security settings

2. Content Creation and Management Forms
For educators and content creators, forms facilitate efficient content development:

- **Question Creation Form:** Rich text editor with support for multimedia, LaTeX equations, and multiple question types (MCQ, subjective, true/false, fill-in-the-blank)

- **Exam Builder Form:** Drag-and-drop interface for exam creation with time limits, difficulty settings, and question bank integration

- **Category Management:** Hierarchical category creation with tagging and metadata support

3. Assessment and Evaluation Forms
The assessment forms leverage AI capabilities while maintaining user control:

- **Exam Taking Interface:** Clean, distraction-free design with progress indicators, time management, and auto-save functionality

- **Manual Evaluation Form:** Structured rubric-based evaluation with AI assistance suggestions and override capabilities

- **Feedback Forms:** Comprehensive feedback collection with rating systems and qualitative input options

4. Analytics and Reporting Forms
Data-driven forms support informed decision-making:

- **Report Generation Form:** Customizable report parameters with real-time preview and export options

- **Analytics Dashboard Configuration:** Personalized dashboard setup with widget selection and layout customization

- **Performance Tracking Forms:** Progress monitoring with goal setting and achievement tracking

4.4.3 Technical Implementation

Frontend Framework: Modern JavaScript frameworks (React/Vue.js) with component-based architecture ensure consistency and maintainability.

Form Validation: Multi-layer validation approach:

- **Client-side:** Real-time validation using JavaScript for immediate feedback

- **Server-side:** Comprehensive validation ensuring data integrity and security

- **Database-level:** Constraint enforcement as the final validation layer

Offline Support: Service workers and local storage enable form completion without internet connectivity, with automatic sync upon reconnection.

Security Measures: CSRF protection, input sanitization, and encrypted data transmission ensure secure form processing.

4.4.4 User Experience Enhancements

Smart Form Features:

- **Auto-complete:** Intelligent suggestions based on user history and common inputs

- **Dynamic Fields:** Conditional field display based on user selections

- **Progress Indicators:** Clear visual feedback on form completion status

- **Save Draft:** Automatic saving of form progress to prevent data loss

  Accessibility Features:

- **Keyboard Navigation:** Full keyboard accessibility with logical tab order

- **Screen Reader Support:** Proper ARIA labels and descriptions

- **High Contrast Mode:** Visual accessibility options for users with visual impairments

- **Font Size Adjustment:** Customizable text size for improved readability

4.5 Conclusion

This comprehensive system design successfully addresses the critical challenges identified in Chorcha's current educational platform while establishing a robust foundation for future growth and scalability. The proposed solution integrates advanced AI capabilities, enhanced user experience design, and optimized system architecture to create a transformative educational technology platform.

4.5.1 Key Achievements

Problem Resolution: The design successfully addresses all five critical problems identified in Chapter 1:

1. **Scalability Crisis Resolved:** AI-powered evaluation handles 80% of assessment tasks automatically, reducing manual workload and supporting unlimited concurrent users

2. **Performance Optimization:** Load balancing, intelligent caching, and database optimization ensure 95% uptime during peak periods with 80% faster query responses

3. **Real-time Capabilities:** Instant report generation, live analytics dashboards, and immediate feedback replace delayed manual processes

4. **Enhanced Accessibility:** Offline functionality ensures equitable access regardless of connectivity, supporting Bangladesh's diverse technological landscape

5. **System Reliability:** Optimized data architecture eliminates timeout errors and lock contention issues through strategic database design

Technical Innovation: The system incorporates cutting-edge technologies including natural language processing for assessment evaluation, machine learning for adaptive questioning, and progressive web application architecture for seamless offline experiences.

User-Centric Design: Comprehensive form design and user interface improvements prioritize accessibility, usability, and engagement across all user roles (students, teachers, administrators, content creators).

4.5.2   Implementation Impact

Educational Transformation: The enhanced system positions Chorcha as a leader in educational technology, supporting personalized learning experiences and data-driven educational insights.

Operational Efficiency: Automated evaluation processes and intelligent system management reduce administrative overhead while improving assessment quality and consistency.

Scalability Foundation: The modular architecture and cloud-ready design ensure the platform can grow from thousands to millions of users without compromising performance or user experience.

Data-Driven Insights: Advanced analytics capabilities provide educators and administrators with actionable insights for improving educational outcomes and system optimization.

4.5.3   Future Readiness

The designed system architecture provides a solid foundation for future enhancements:

- **AI Evolution:** Modular AI components can be upgraded as natural language processing and machine learning technologies advance

- **Integration Capability:** RESTful APIs and microservices architecture enable seamless integration with external educational tools and platforms

- **Emerging Technologies:** The flexible architecture can accommodate future technologies such as virtual reality, blockchain credentialing, and advanced analytics

- **Global Expansion:** Multi-language support and cultural adaptability features enable international deployment

4.5.4   Success Metrics

The implementation success will be measured through:

- **Performance Metrics:** 95% system uptime, sub-2-second response times, and zero timeout errors

- **User Engagement:** Increased platform usage, improved completion rates, and positive user satisfaction scores

- **Educational Outcomes:** Enhanced learning analytics, improved assessment quality, and measurable educational impact

- **Operational Efficiency:** Reduced manual evaluation time, automated report generation, and streamlined administrative processes

4.5.5   Final Recommendation

Based on the comprehensive analysis, design, and feasibility assessment presented throughout this document, we strongly recommend the immediate implementation of the proposed enhanced system design. The solution addresses critical operational challenges while positioning Chorcha for sustainable growth and educational innovation.

The phased implementation approach ensures minimal disruption to current operations while delivering immediate benefits to users. The robust technical architecture, user-centric design, and comprehensive feature set create a competitive advantage in the rapidly evolving educational technology landscape.

This system design represents not just a solution to current problems, but a strategic investment in Chorcha's future as a leading educational technology platform serving students, educators, and institutions across Bangladesh and beyond.