



**IMT 589 Spr 2025**

**Group 7: Education**

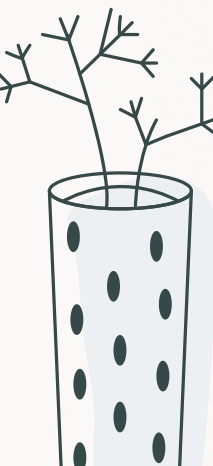
# **SmartEd Recommender: Cloud-Based Personalized Recommendations for Educators and Students**

***By:***

***Apeksha Tejawani, Ishika Johari,  
Sneha Reddy, Sukhmandeep Kaur***

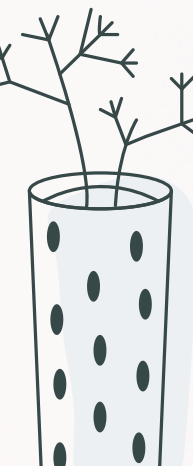
# Table of Content

- Industry Overview
- Company Objectives, Problems and Business Model
  - Company Introduction
  - Business Problems
  - Changes in the Business Model and Boosting Revenues
- Our Cloud Strategy and Solution
  - Cloud Models
  - Cloud Solution Justification
  - Alignment with Company Goals
  - Partnership with CFO
  - User Flow
  - Mockup
  - Proposed High- level Architecture
  - Functional Requirements
  - Main Cloud Components used in the Present Architecture
  - Cloud Deployment Models and Strategy
  - Migration Strategy (deployment and implementation)
- Effects on Organizational Structure
  - IT Department Operations and Personnel, Other teams
  - Changes to Help the Technical Support Organization Align with the Strategy
- Regulations and Compliances
- Cloud Solution Limitations
- Future Extensions
- References
- Appendix
- Contributions from Team Members



1

## Industry Overview





# Industry Overview for Education

The US higher education industry is undergoing rapid transformation, driven by the convergence of digital disruption, shifting student expectations, and increasing scrutiny around ROI in education. Leading institutions are expected to provide not just academic excellence but also clear career pathways, personalised learning experiences, and technological sophistication.

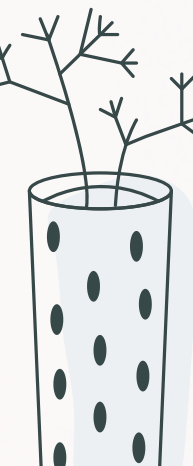


## Key Industry Trends

- **AI and Data-Driven Personalisation:** Institutions are using AI to personalise course selection, advising, and career guidance
- **Hybrid and Online Learning Models:** Post-COVID demand for flexibility has led to scaled-up digital infrastructure and learning analytics
- **Skills-First Education Models:** There is growing emphasis on employability, competency-based learning, and aligning curriculum with market needs
- **Funding Pressures and Efficiency Demands:** Public universities like UW must balance affordability with operational efficiency and innovation

2

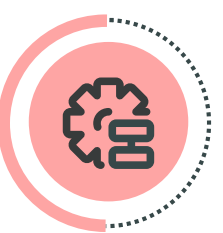
## **Company Objectives, Problems and Business Model**





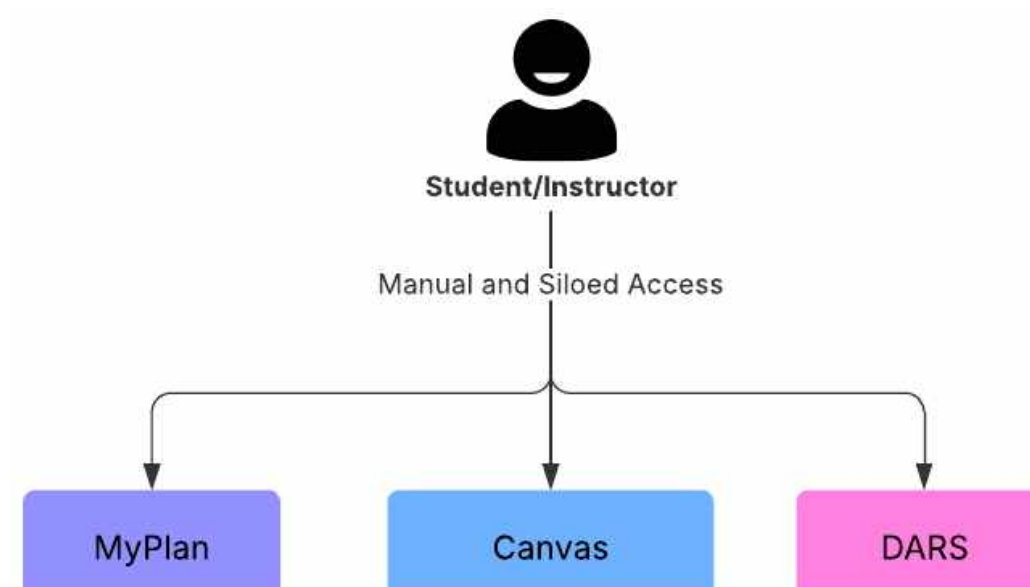
## Who are we?

- We are UW-IT: the backbone of digital infrastructure at UW. Our mission is to empower students, faculty, and staff through seamless, secure, and forward-thinking technology solutions.
- UW-IT currently operates on on-premise data centers, which limit scalability and agility. To modernize its infrastructure, UW-IT is migrating core systems to Microsoft Azure, aiming for greater flexibility, security, and innovation through cloud adoption over the next five years.

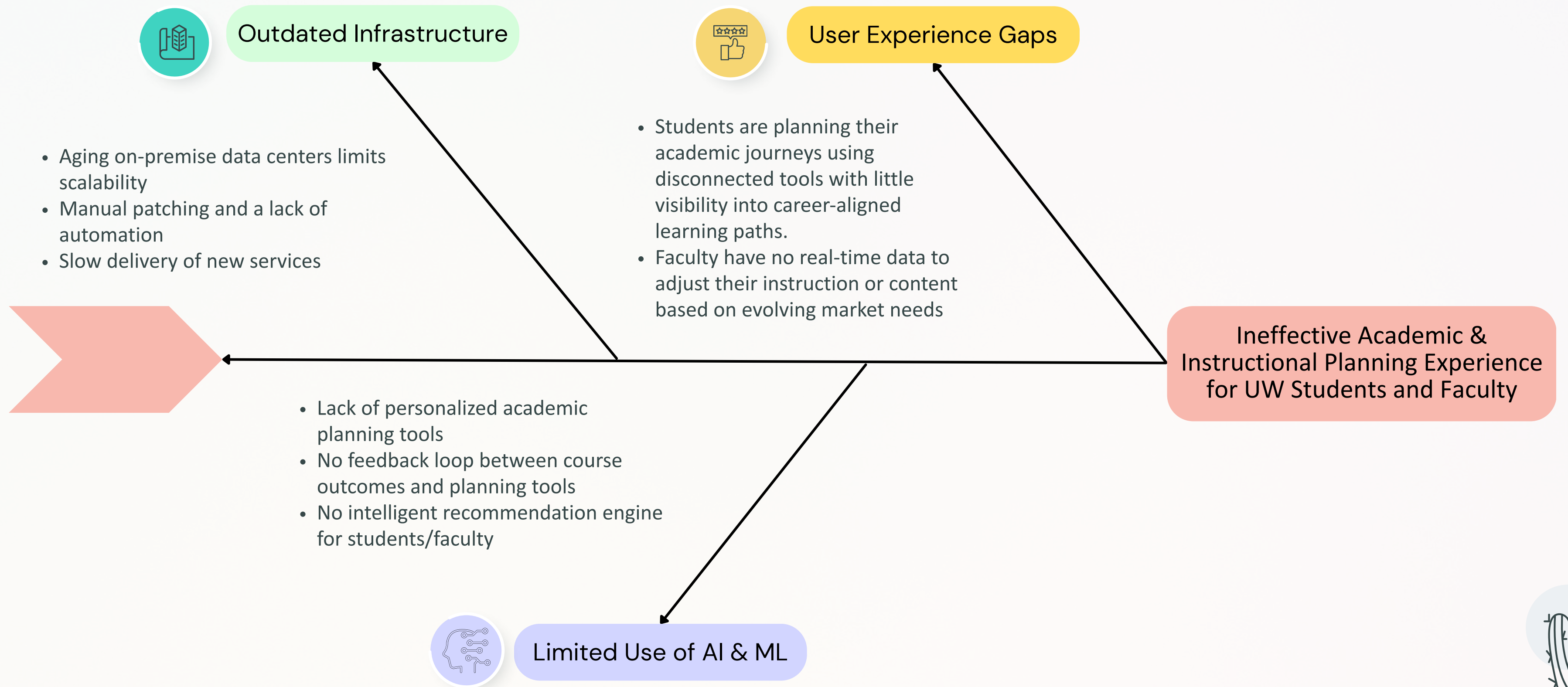


## Current Scenario: Fragmented academic planning experience

- UW IT also supports core **academic tools like MyPlan, Canvas, and DARS**, each essential to the student journey — from course planning to classroom learning and degree audits.
- While these systems are functional, they operate independently, creating a fragmented planning experience. Students often need to manually integrate information from these separate platforms to piece together their academic and career goals. This lack of integration can result in limited personalized guidance. Additionally, instructors may not have comprehensive insights into student progression across these disparate systems.



# Business Problem Identification



Together, these issues form the foundation of the disconnected student and faculty experience



# Our Solution: SmartED Recommender

A **personalized academic and instructional recommender system hosted on the cloud.**, integrated directly into existing systems, designed to:

- Suggest personalized courses based on chosen career paths for students
- Support faculty with dynamic content and assignment recommendations
- Align academic choices with job market trends and student aspirations



## For Students:

Personalized course and career path recommendations



## For Faculty:

AI-driven suggestions for content, assignments, and emerging topics

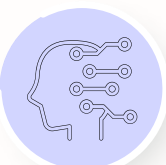
### Business Problem



Outdated Infrastructure



User Experience Gaps



Limited Use of AI & ML

### How SmartEd Solves It

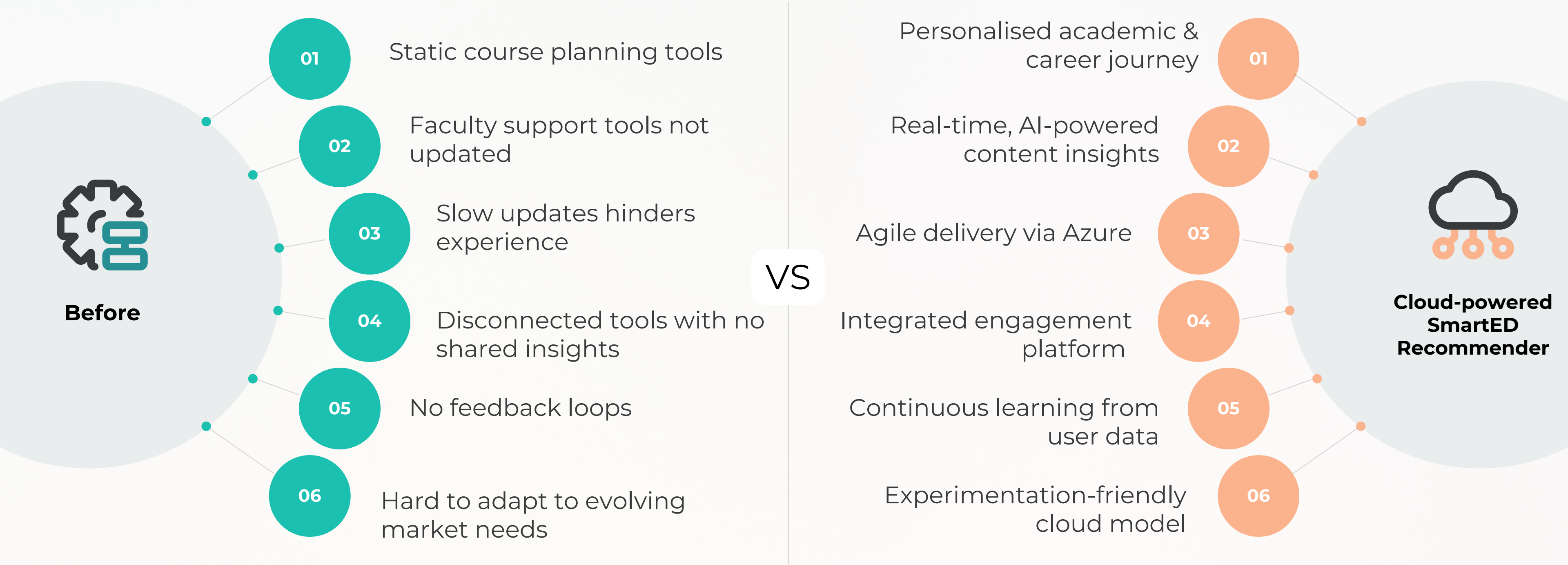
Azure PaaS/SaaS architecture supports auto-scaling

Real-time, personalized recommendations bridge the planning and insight gap

Azure Machine Learning powers dynamic recommendations and builds a feedback loop



# Changes in the Business Model: Improving Student & Faculty Experiences



SmartED Recommender transforms UW’s planning experience - making it personalized, data-driven, and future-ready for every student and instructor

# How SmartED Recommender can boost UW revenue?

SmartEd lets UW grow revenue per student, not just number of students, while protecting brand equity

## Premium Pricing Power

- SmartEd lets UW justify tuition increases by adding AI-driven value (e.g., 'personalized career alignment'). It can attract higher-paying students: Out-of-state (3× tuition) and international students (5× tuition) pay premiums for cutting-edge tools.
- **Impact:** Even a 1-2% tuition premium generates millions annually without expanding seats.



## Retention & Graduation Rate Optimization

- UW's 6-year graduation rate is ~84%. Improving this by even 1% (e.g., reducing dropouts via better planning) protects \$12M+ yearly revenue (1% of 36K undergrads × \$40K avg. tuition).
- Bonus:** Higher graduation rates boost rankings, reinforcing prestige.



## Attracting Corporate Partnerships & Grants

UW is already a research powerhouse with connections to tech firms and public sector funders. SmartEd's data-driven academic alignment supports grant eligibility (e.g., NSF, DoE) and industry-funded upskilling pilots.



## Operational Efficiency

- UW still wastes resources on manual advising (can be replaced by SmartEd's automation) and redundant course scheduling (AI optimizes demand predictions).
- **Impact:** Savings can be redirected to high-ROI areas (e.g., faculty hires, research).



3

## Our Cloud Strategy and Solution

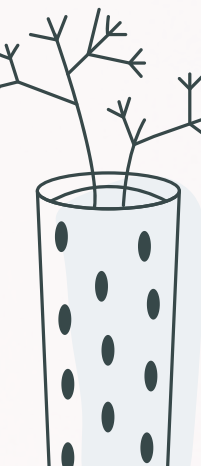




## High level cloud strategy

The University of Washington (UW) currently operates with fragmented and outdated on-premise infrastructure. Students rely on disconnected systems like MyPlan, Canvas, and DARS, resulting in limited personalization, redundant planning efforts, and no unified insight into academic or career trajectories. Faculty face a lack of real-time data and limited tools to adapt instruction dynamically.

To modernize this experience, UW-IT is adopting a cloud-first approach. The high-level strategy centers around migrating to Microsoft Azure, leveraging public cloud infrastructure and Platform-as-a-Service (PaaS) components to enable scalability, integration, and intelligent services. The vision is to evolve from legacy static systems to a secure, flexible, and innovation-ready academic technology stack over the next five years.



# Short Term Cloud Strategy (0–18 Months): Key elements



- **Modernize identity and access management** : Unify authentication across MyPlan, DARS, and Canvas using Azure Active Directory. This ensures secure, role-based access for students and faculty while laying the foundation for a consistent user experience across systems.
- **Build an integration layer using Azure APIs** : Develop a cloud-native integration layer using Azure API Management and Logic Apps. This will allow these systems to share data in real time, reducing friction for students and enabling richer insights for advisors.
- **Launch the SmartEd Recommender as a pilot** : Introduce SmartEd as a secure, Azure-hosted pilot application that provides students with personalized course and career recommendations. By pulling data from MyPlan and DARS, this tool can offer immediate value while testing integration capabilities.
- **Create faculty dashboards for student progress** : Design user-friendly dashboards using Power BI that allow faculty and advisors to view consolidated student data from Canvas, DARS, and MyPlan. This supports better academic advising and early intervention.
- **Begin targeted cloud migration efforts** : Migrate selected components of MyPlan and DARS to Azure infrastructure. Starting with lower-risk workloads helps UW-IT build internal expertise and validate performance improvements before scaling up.

# Long Term Cloud Strategy (18 Months to 5 Years): Key elements

- **Complete migration of academic systems to Azure** : Transition the full backend infrastructure of MyPlan and DARS to Microsoft Azure using cloud-native services. This shift will enhance reliability, reduce maintenance costs, and increase system agility.
- **Develop a unified academic experience platform** : Create or extend an integrated platform that combines academic planning, degree progress tracking, and learning management in one interface. This central hub will simplify how students navigate their academic journey and provide them with a more personalized and proactive experience.
- **Enhance the SmartEd Recommender with advanced AI** : Use Azure Machine Learning to expand SmartEd's capabilities. The system can evolve to offer tailored course paths, internship suggestions, and learning opportunities based on real-time academic data and individual goals.
- **Establish an institutional analytics framework** : Build an enterprise analytics environment using Azure Synapse and Data Lake to support institutional reporting, student success tracking, and academic planning. This will provide UW with deeper insights into student engagement and program outcomes.
- **Evaluate hybrid and multi-cloud strategies** : As cloud adoption matures, explore hybrid or multi-cloud deployments to strengthen business continuity, reduce vendor lock-in, and meet evolving compliance requirements. Use containerized services and cloud-agnostic development tools to support flexibility and scale.
- **Strengthen data governance and privacy frameworks** : Develop clear policies and oversight for how student data is used in analytics and personalization. Ensure compliance with FERPA and university data values by embedding governance into each stage of the platform's evolution.





# Cloud Experimentation Strategy

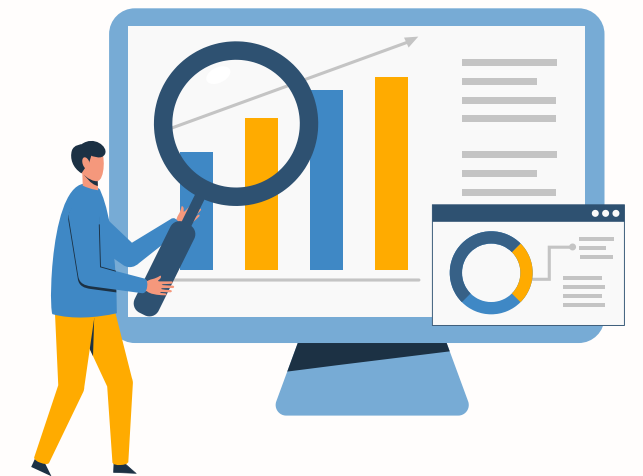
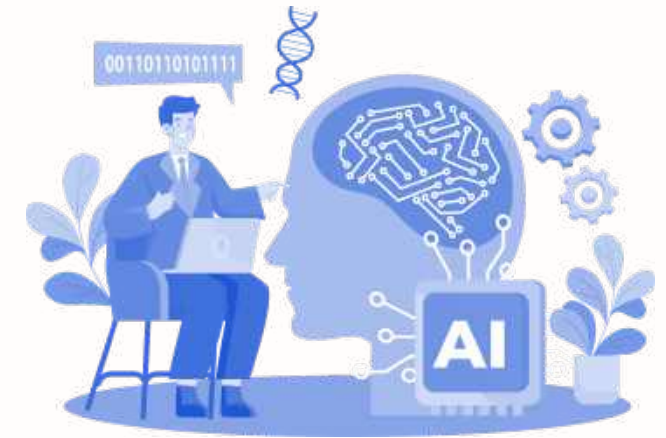
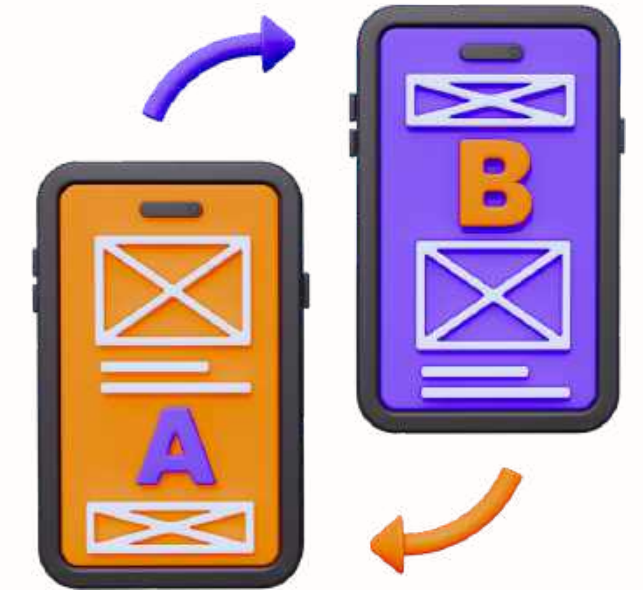
Cloud experimentation is fundamental to both the immediate agility and long-term innovation of the University of Washington's academic planning transformation. Microsoft Azure's cloud-native capabilities empower UW-IT to test, iterate, and continuously enhance SmartEd, avoiding the costs and inflexibility associated with traditional IT systems.

In the short term, over the next 0 to 18 months, experimentation allows the SmartEd team to pilot and refine features of the SmartEd Recommender before full-scale deployment. It enables safe testing of integrations among MyPlan, DARS, and Canvas with minimal operational risk, while gathering early user feedback to improve both the interface and AI-driven recommendations. This approach accelerates deployment by validating core functionalities in real-world environments.

Looking toward the long term, from 18 months to 5 years, cloud experimentation supports continuous refinement of AI models through A/B testing and analysis of real usage data. It also facilitates experimentation with advanced predictive analytics and faculty dashboards using Azure Synapse. As UW's academic requirements and technologies evolve, the team can safely explore new features and cultivate a culture of innovation by trialing emerging cloud services with low risk.

Strategically, embedding experimentation into the cloud strategy enhances UW's agility and responsiveness, reduces the time-to-market for new features, and strengthens alignment with student-centered goals. The scalable infrastructure of Azure supports sustainable innovation, ensuring that SmartEd remains relevant and effective.

In conclusion, cloud experimentation is not an optional activity but a strategic imperative. It accelerates SmartEd's evolution in alignment with student needs, minimizes risks associated with change, and maximizes UW's institutional impact on academic success.



# Alignment of cloud strategy with company goals

The SmartED cloud strategy is directly aligned with UW-IT's broader institutional goals of enabling accessibility, innovation, and student success through technology. Key alignment points include:

- **Goal: Enhance Student Experience**

- Alignment: SmartED provides real-time, personalized course and career recommendations, replacing fragmented planning tools with a unified, intelligent dashboard.

- **Goal: Empower Faculty with Better Tools**

- Alignment: Faculty receive actionable insights for dynamic instruction, powered by Azure ML and data integration across platforms.

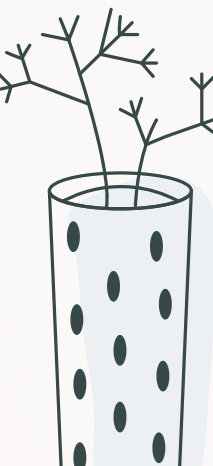
- **Goal: Modernize Infrastructure for Scalability and Agility**

- Alignment: By moving to Azure's PaaS and SaaS offerings, UW-IT reduces dependency on aging on-premise systems, enabling rapid deployment, experimentation, and continuous delivery.

- **Goal: Ensure Security and Compliance (e.g., FERPA)**

- Alignment: Azure's FERPA-compliant services and native integration with Azure Active Directory support secure, role-based access and data governance.

Together, these elements demonstrate how the SmartED cloud strategy is not a standalone tech upgrade but a core enabler of UW's academic, operational, and innovation missions.



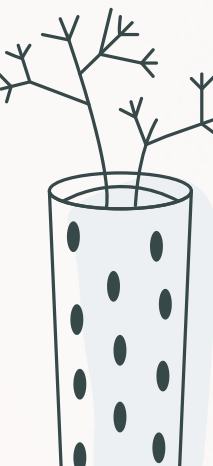


# Involvement of the CFO for the success of the strategy

The Chief Financial Officer (CFO) plays a pivotal role in driving the success of SmartED's cloud strategy. Since cloud transformation involves upfront investment, changes in budgeting models (from CapEx to OpEx), and long-term financial planning, the CFO's strategic oversight ensures:

- **Budget Realignment:** Approving the shift from fixed infrastructure spending to a more flexible, subscription-based SaaS model.
- **ROI Tracking:** Collaborating with IT and academic leadership to define financial KPIs and track ROI in terms of operational cost savings, improved student retention, and increased instructional efficiency.
- **Risk Management:** Evaluating the financial implications of security, compliance, and scalability risks associated with cloud migration.
- **Vendor Negotiations:** Leading licensing and pricing negotiations with Microsoft Azure to secure educational discounts and favorable terms through university-wide agreements.

Active CFO participation ensures that cloud investments are financially sustainable, strategically aligned, and support data-informed decisions across university leadership.





# MultiCloud Considerations

We have intentionally chosen not to adopt a multi-cloud approach in the short term. Early-stage product development benefits from maintaining a singular focus, and consolidating services within Azure allows for reduced complexity, streamlined operations, and better cost control.

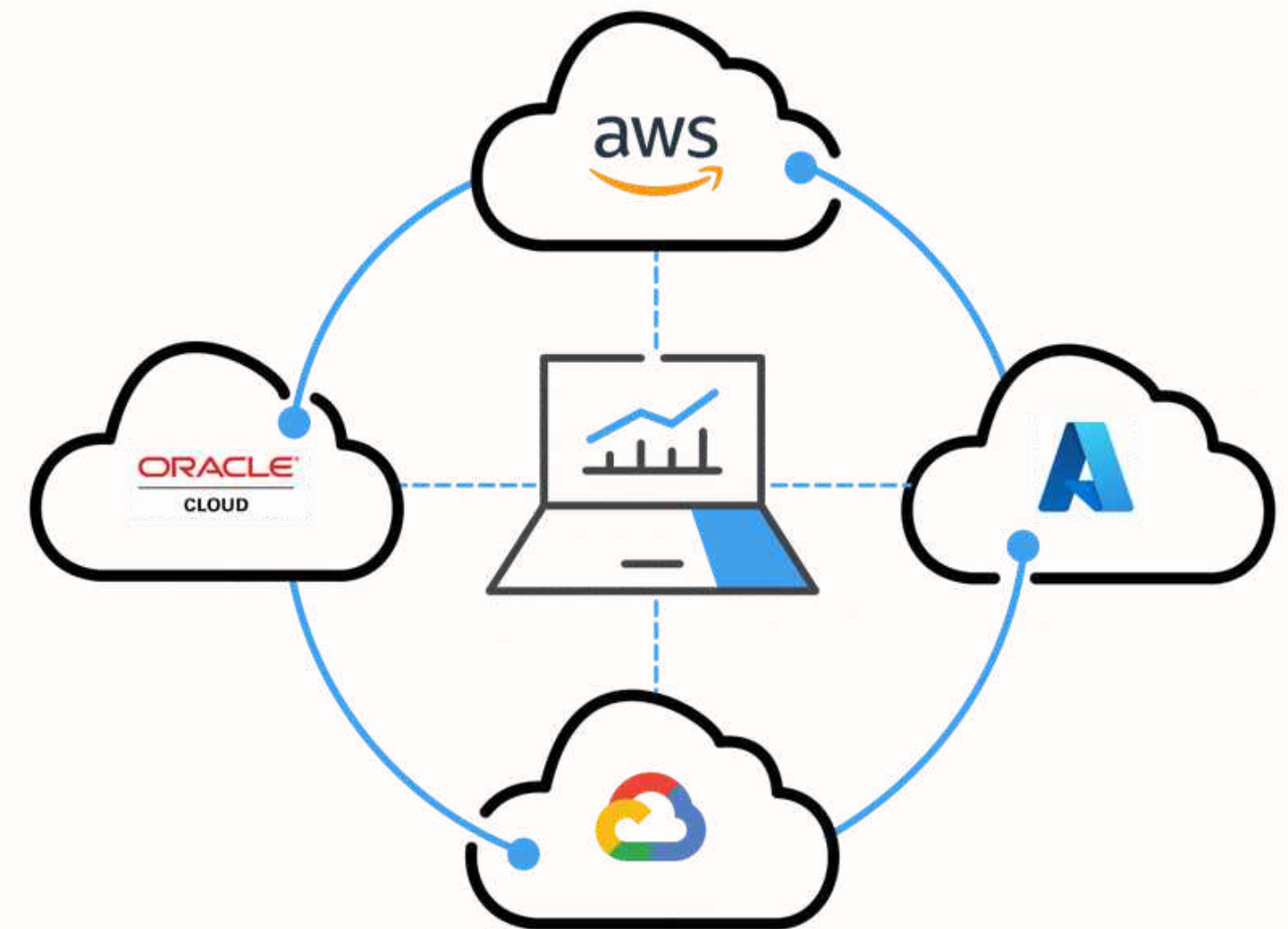
**However, we recognize that a multi-cloud strategy may offer strategic benefits as SmartEd matures. These include:**

- Avoiding vendor lock-in and gaining leverage in negotiations.
- Meeting regional data residency or compliance requirements that may arise due to evolving educational data privacy laws.
- Improving disaster recovery and business continuity by distributing services across cloud providers.

**Key challenges that will need to be addressed before implementing a multi-cloud environment include:**

- Ensuring platform consistency across different providers.
- Managing higher operational complexity, especially in monitoring, DevOps, and security.
- Developing portable, containerized services using technologies like Docker and Kubernetes to maintain flexibility and ease of migration.

We will continue to monitor the scalability, cost, and compliance landscape and revisit this approach based on institutional needs, user growth, and technology trends.



# Justification of Public Cloud

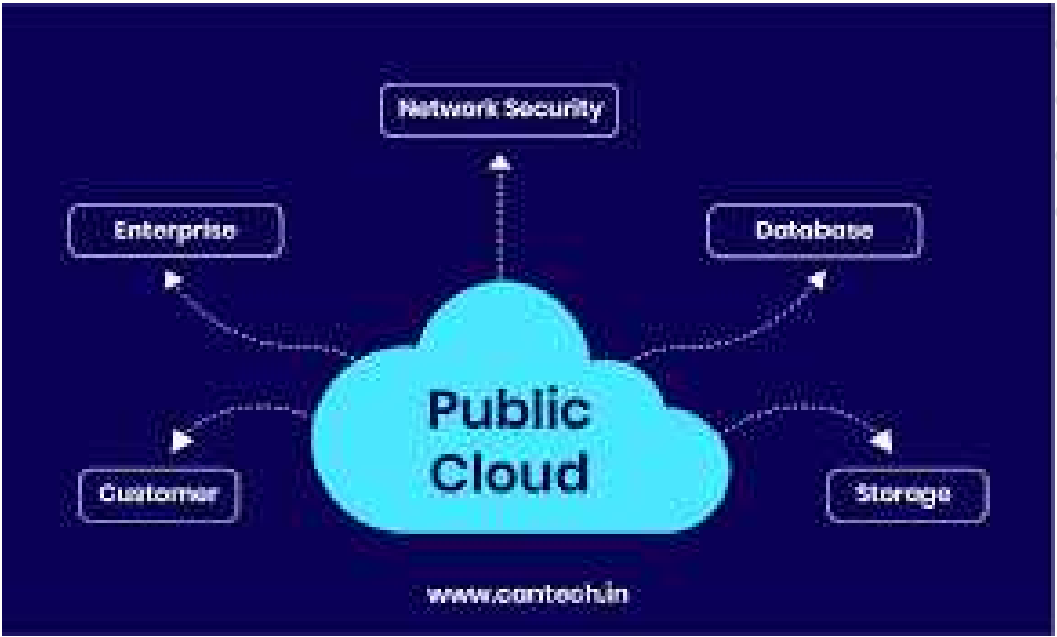
Adopting a public cloud aligns closely with UW’s established cloud-first strategy. Public cloud providers like Microsoft Azure offer scalable and secure infrastructure designed to support growing workloads while embedding regulatory compliance requirements, such as FERPA, natively within the platform. This integration significantly reduces the compliance burden for UW-IT and enhances data protection.

Furthermore, migrating to a public cloud reduces reliance on UW’s aging on-premises data centers. On-premises systems often limit agility and impose high maintenance overhead. By leveraging the cloud’s elasticity and global reach, SmartEd can better handle fluctuating usage patterns and innovate rapidly.

Table 1: Public Cloud Model Evaluation

Aspect	Why It Matters	How Azure Public Cloud Fits SmartEd	Key Takeaway
Scalability & Agility	Ability to grow and adapt with demand	Azure’s elastic infrastructure easily scales without disruption	Supports future growth without complexity
Compliance	Meeting legal and institutional security requirements	Built-in FERPA and industry certifications simplify compliance	Minimizes UW-IT overhead on regulatory efforts
Cost & Operational Complexity	Budget impact and IT resource demands	Public cloud lowers costs and reduces infrastructure management	More cost-effective and less operational burden
Fit for SmartEd’s Needs	Suitability based on data sensitivity and workload	Ideal for SmartEd’s moderate data use, no need for sensitive local	Public cloud aligns perfectly with SmartEd requirements

Alternative deployment models such as private or hybrid clouds introduce greater complexity and operational costs, which are not justified by SmartEd’s relatively moderate data storage and processing needs. Private clouds require significant infrastructure management and higher expenses, while hybrid clouds add integration challenges and operational overhead without clear benefits for this use case. Therefore, a public cloud model on Azure offers the best balance of security, scalability, and cost-effectiveness aligned with UW-IT’s cloud-first strategy and SmartEd’s goals.



# Justification SaaS Delivery Model with Azure PaaS Backend

SmartEd is delivered as a Software as a Service (SaaS) solution, which ensures the platform is fully managed and ready for immediate use. This approach reduces the need for UW-IT to manage the underlying infrastructure and application layers directly, allowing the team to focus on system integration, user support, and continuous innovation. SaaS also provides seamless interoperability with UW’s existing academic platforms such as Canvas, MyPlan, and DARS. This smooth integration is crucial to addressing the current fragmentation in academic planning and delivering a unified, streamlined user experience.

While SaaS offers low IT overhead and fast deployment, it typically provides less control over infrastructure. In contrast, Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) provide greater customization but require UW-IT to manage more operational complexity, which can slow agility and increase workload.To balance these needs, SmartEd’s backend is built using Azure’s Platform as a Service offerings, including Azure App Service, Azure SQL Database, and Azure Machine Learning Studio. This hybrid approach combines the ease and management benefits of SaaS with the flexibility and customization power of PaaS. Azure PaaS supports rapid, scalable development and continuous delivery, enabling SmartEd to integrate advanced AI-driven personalization features essential to its mission.

Deployment Model / Feature	Key Advantages	Considerations / Limitations
SaaS (Software as a Service)	Fully managed and ready to use, minimizing UW-IT’s operational burden. Enables quick deployment and seamless integration with existing UW academic platforms.	Limited ability to customize underlying infrastructure or backend logic. May constrain advanced feature development.
IaaS / PaaS (Infrastructure / Platform as a Service)	Offers deep control and customization of infrastructure and applications, allowing tailored solutions to meet specific needs. Provides flexibility for future enhancements.	Increases operational complexity and IT management overhead. Deployment cycles can be longer, potentially slowing innovation.
Azure PaaS for Backend Development	Accelerates development with scalable, managed services. Supports advanced AI and machine learning integration essential for SmartEd’s personalized recommendations. Allows flexible customization of workflows and data models.	Requires skilled development resources to leverage platform effectively. Some platform management responsibilities remain.



Choosing a SaaS delivery model paired with Azure PaaS services offers the perfect balance of ease, control, and innovation for SmartEd. SaaS ensures rapid deployment and minimal IT overhead, while Azure PaaS provides the necessary flexibility and scalability to customize features and incorporate advanced AI capabilities. Together, they empower SmartEd to effectively meet UW’s evolving academic needs with a future-ready, personalized, and scalable platform.



# Cloud Provider Options - Azure



Criteria	Microsoft Azure (Chosen)	AWS	Google Cloud (GCP)
Education Ecosystem Integration	Seamless with Teams, OneDrive, Outlook, Office 365	Limited LMS and Microsoft tool integration	Weaker presence in higher-ed tools
Compliance & Certifications	Strong FERPA, SOC 2 support tailored to education	Strong, but enterprise-oriented	Less tailored documentation for education use
Identity & Access Management	Azure AD integrates natively with UW systems	Requires custom IAM setup	GCP IAM less aligned with legacy systems
Existing University Licensing	Cost-effective via UW-wide Microsoft agreements	No existing licensing advantage	Fewer bundled education discounts
Integration with Legacy Systems	High — aligns with existing UW platforms (MyPlan, DARS)	Moderate — requires more customization	Best for greenfield projects, less for legacy tie-in
Developer Productivity Tools	Azure App Services, DevOps, Monitoring — ready out-of-the-box	Strong tools, but steeper learning curve	Great for AI, but less turnkey for education stack
AI/ML Capabilities	Azure ML Studio fits academic recommender use case	Powerful, but complex integrations	Excellent — but better suited for data-first orgs

## Why Azure?

Microsoft Azure was chosen over AWS and Google Cloud because it offers the best alignment with the University of Washington’s existing infrastructure, educational tools, and compliance needs. Azure integrates seamlessly with widely used campus systems like Office 365, MyPlan, and DARS, while also providing native support for UW’s identity management through Azure AD. Its strong education-focused compliance (e.g., FERPA), cost efficiency through existing campus-wide Microsoft licensing, and turnkey developer tools make it the most strategic and practical choice. In contrast, AWS and GCP would require more customization, lack native integration with UW’s systems, and offer fewer educational pricing advantages.

# End to End User Flow with SmartEd Recommender



## Unified Academic Dashboard

- Centralized platform integrates MyPlan, DARS, and Canvas in one view.
- Provides a holistic picture of academic planning, degree progress, and co-curriculars.
- Real-time updates on courses, graduation requirements, and market-aligned career resources.

## Interactive Planning

- Students simulate “what-if” course paths and program changes.
- Visual planning tools help map out timelines and graduation pathways.
- Recommendations evolve continuously based on student feedback and academic performance.

## Secure Login & Compliance

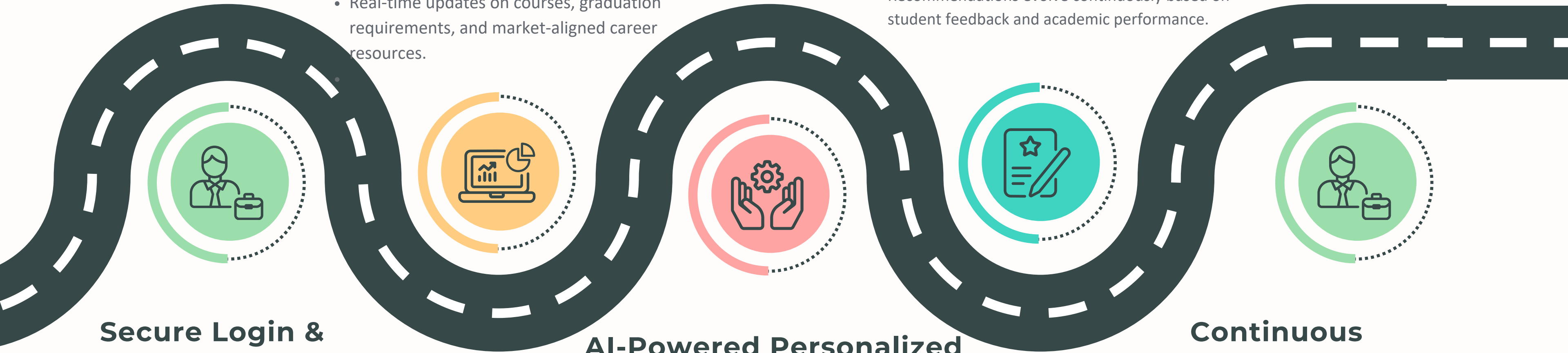
- Students and faculty authenticate through UW’s Azure Active Directory.
- Role-based access ensures users only see relevant data.
- FERPA-compliant data handling with transparent audit trails and encryption.

## AI-Powered Personalized Recommendations

- SmartEd analyzes academic history, declared interests, and labor trends.
- Suggests tailored courses, minors, certifications, and career paths.
- Faculty and advisors access student-level insights for proactive academic support.

## Continuous Improvement & Support

- System automatically collects data on outcomes, satisfaction, and system interactions.
- AI models retrain using performance metrics to enhance future recommendations.
- Integrated chatbots and virtual assistants offer guidance, alerts, and milestone reminders.



# Mockup Website - Student View

This mockup presents the student-facing interface of UW-IT's SmartED Recommender, a cloud-powered platform designed to deliver personalized academic planning through AI-driven insights. It features a streamlined dashboard where students like Jamie Smith can view and update their academic background, work experience, and career goals. Based on this information, the system intelligently recommends relevant skills and tailored courses that align with the student's selected career path, such as Product Manager. Skill proficiency is visually represented with progress indicators, and each skill includes direct links to curated course options. By integrating data from previously siloed systems into a cohesive, user-friendly experience, SmartED enhances academic planning and career alignment while leveraging the scalability and intelligence of Microsoft Azure.

SmartEd Recommender

Notifications

JS Jamie Smith

JS

Jamie Smith

Computer Science, Year 3

University of Technology

Profile Completion85%

✓ Basic Information

✓ Education history

✓ Work experience

⚠ Skills assessment

✗ Career preferences

✍ Complete your profile

Your Background

Education

BSc Computer Science

University of Technology, 2021-Present

GPA: 3.8/4.0

✍

+ Add education

Work Experience

Software Development Intern

TechCorp, Summer 2022

Worked on front-end development for customer-facing applications

✍

+ Add experience

Future Aspirations

I'm interested in product management roles that combine technical knowledge with business strategy. I want to work at a tech company that values innovation and provides opportunities for continuous learning and growth.

Chosen Career Path: Product Manager

AI Matched

Product Managers lead the development of products from conception to launch, working with cross-functional teams to ensure success. Based on your background and interests, here are the top skills to focus on:

User Research & Customer EmpathyFind Courses85%

Based on UX Design course and internship experience

Data Analysis & Decision MakingFind Courses70%

Based on Statistics and Data Science courses

Strategic ThinkingFind Courses45%

Consider taking Business Strategy courses

Technical KnowledgeFind Courses85%

Strong from Computer Science background

Communication & LeadershipFind Courses50%

Consider joining student leadership organizations

Find All Product Management Courses

AI Recommended Courses

Plan My Degree

MGMT 301: Product Management Fundamentals

Spring 20243 CreditsCore Requirement

Introduction to product management principles, methodologies, and best practices. Learn how to identify customer needs, define product vision, and create roadmaps.

Add to PlanView Details

MKT 250: User Research Methods

Fall 20234 CreditsElective

Learn qualitative and quantitative research methods to understand user needs and behaviors. Includes hands-on practice with user interviews, surveys, and usability testing.

Add to PlanView Details

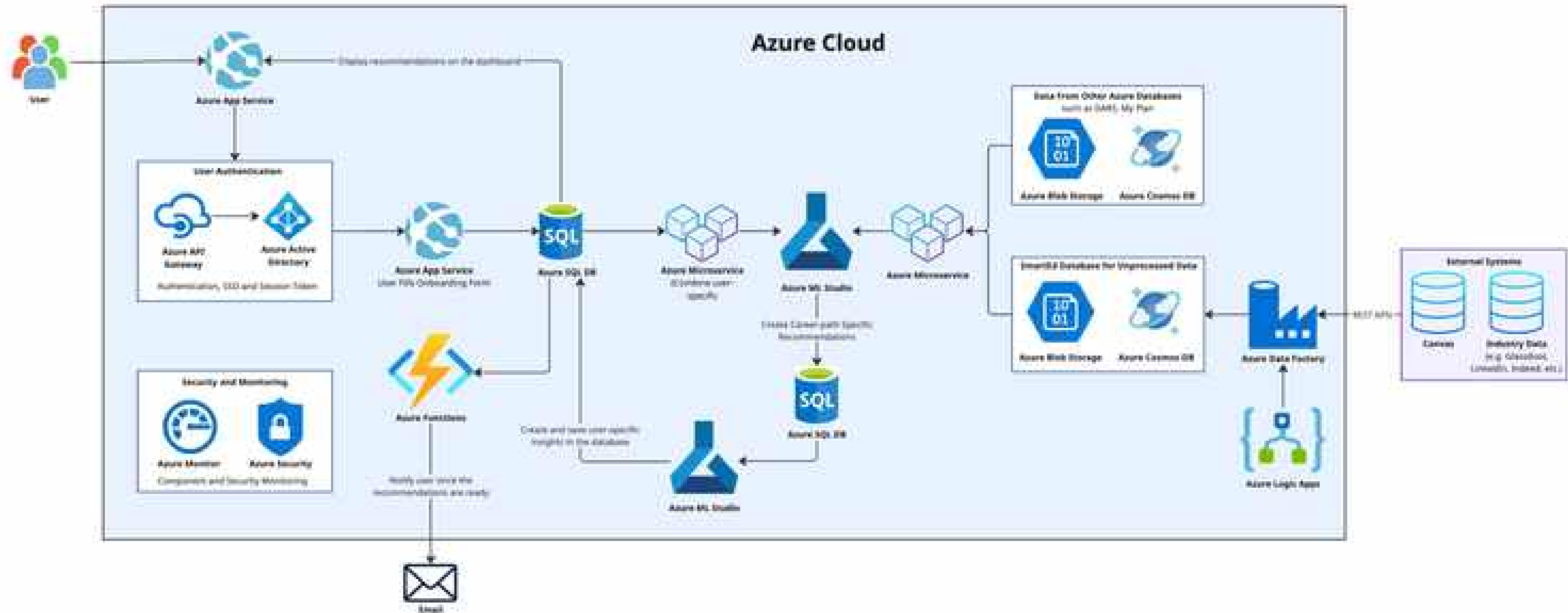


# Architecture Details

Component	Azure Service	Purpose
Identity & Access	Azure Active Directory	Provides secure, centralized authentication and role-based access control for students, faculty, and staff. Supports single sign-on (SSO) across UW systems to ensure seamless and secure login experiences.
Application Hosting	Azure App Service	Hosts the SmartEd Recommender web application on a fully managed, scalable platform that automatically adjusts resources based on user demand. Enables rapid deployment and easy updates without downtime.
API Integration	Azure API Management	Acts as a gateway to connect SmartEd with external academic systems such as Canvas, DegreeWorks, and MyPlan. Enables secure, scalable, and real-time data exchange to unify student information and academic resources.
Structured Data Storage	Azure SQL Database	Stores critical academic information, including student profiles, course catalogs, enrollment records, and degree requirements. Supports transactional integrity and fast querying to power real-time recommendations.
Unstructured Data Storage	Azure Cosmos DB	Handles storage of non-relational data such as system logs, machine learning outputs, user interaction data, and other auxiliary information needed to enhance AI-driven features and analytics.
AI & Recommendation Engine	Azure Machine Learning	Provides the infrastructure for building, training, and deploying AI models that generate personalized course and career recommendations based on students' academic progress, skills, and labor market trends.
Monitoring & Insights	Azure Monitor and Application Insights	Offers end-to-end monitoring of application health, usage, and performance metrics. Facilitates proactive identification of issues and supports continuous system optimization and reliability improvements.
Security & Compliance	Built-in Azure Compliance Tools	Ensures that SmartEd meets federal and institutional data protection standards, including FERPA and HIPAA. Includes features for data encryption, audit logging, and compliance reporting to safeguard sensitive student information.



# Cloud Architecture Diagram





# Cloud Architecture Flow and Components - 1/3



The architecture begins with users (students and instructors) accessing the system through **Azure App Service**, which serves as the primary web application host and entry point. This service handles all user interactions and automatically scales based on traffic demand while maintaining secure HTTPS connections throughout the user lifecycle.



**Azure API Gateway** acts as the traffic management layer, sitting between the App Service and backend services to control API access, implement rate limiting, and manage service-to-service communication. This gateway ensures that requests flow efficiently through the system while preventing overload conditions that could impact user experience.



**Azure Active Directory** provides the identity backbone for the entire system, managing user authentication with multi-factor authentication capabilities and maintaining session tokens throughout the user journey. This service integrates directly with the App Service to ensure that only authorized users can access platform resources and data.



The data processing lifecycle centers around the **Azure SQL Database** (Primary), which stores core user information, academic records, and application data. This database feeds information into **Azure Machine Learning Studio**, where algorithms process user behavior patterns and academic data to generate personalized learning recommendations and career guidance suggestions.





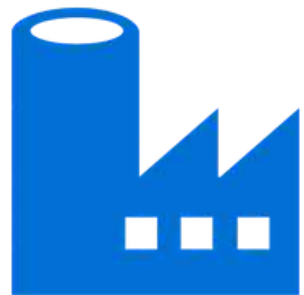
# Cloud Architecture Flow and Components - 2/3



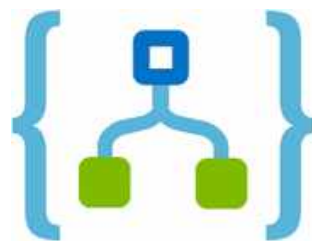
**Azure Machine Learning Studio** represents the intelligence layer of the architecture, creating sophisticated models that analyze user data to produce actionable insights. The ML service outputs its recommendations to **Azure SQL Database (Secondary)**, which serves as the dedicated repository for processed insights and generated recommendations.



**Azure Cosmos Database** provides NoSQL storage capabilities for external academic data, course catalogs, and degree requirements from various institutions. This database integrates with the overall data ecosystem to ensure that recommendations are based on current and comprehensive academic information.



The data integration lifecycle involves **Azure Data Factory** orchestrating ETL operations that extract information from external academic systems, transform the data to match internal schemas, and load processed information into appropriate storage locations.



**Azure Logic Apps** automate monthly data synchronization processes, ensuring that external academic and industry data remains current within the system.



# Cloud Architecture Flow and Components - 3/3



**Azure Blob Storage** handles all file storage requirements, maintaining documents, presentations, and multimedia learning materials that users access throughout their educational journey. This storage integrates with both the Data Factory for automated file processing and the main application for user access.



**Azure Functions** provide serverless computing capabilities that trigger event-driven processes, particularly notification delivery when new recommendations become available. These functions integrate seamlessly with the ML Studio and notification systems to ensure the timely delivery of personalized insights.



The monitoring and security lifecycle encompasses **Azure Monitor**, which continuously tracks system performance across all components and provides real-time visibility into application health.



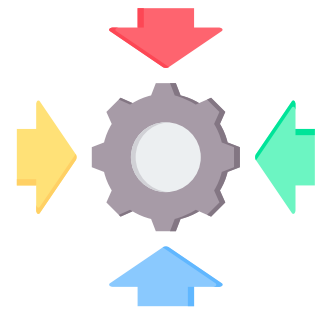
**Azure Security Center** delivers comprehensive threat detection and security management, ensuring that the entire architecture maintains security best practices throughout operation.



# Cloud Architecture Flow and Components - Critical Functions



- **Load Balancing** capabilities are inherently built into Azure App Service, which automatically distributes incoming requests across multiple instances to ensure optimal performance and prevent any single point of failure. The Azure API Gateway further enhances load distribution by implementing intelligent routing algorithms that direct traffic based on the availability and response times of backend services. Azure SQL Database provides built-in load balancing through read replicas and connection pooling, ensuring that database queries are distributed efficiently across available resources.



- **Auto-scaling functionality** operates at multiple levels within the architecture to handle varying workloads dynamically. Azure App Service automatically provisions additional instances during high-traffic periods, such as enrollment seasons, and scales down during low-usage periods to optimize costs. Azure Machine Learning Studio scales compute resources based on the complexity and volume of recommendation processing requirements, ensuring that ML algorithms can handle peak processing demands without performance degradation. Azure Functions scale automatically based on event triggers, spinning up additional instances when recommendation notifications need to be processed and scaling to zero when no events are pending.



- **Security** implementation follows a multi-layered approach throughout the architecture. Azure Active Directory provides the first security layer through robust authentication mechanisms, including multi-factor authentication and conditional access policies that ensure only authorized users can access the system. Database security is enforced through firewall rules that control both read and write access to Azure SQL databases, with additional encryption at rest and in transit for sensitive academic and personal data. Azure Security Center continuously monitors the entire infrastructure for threats, provides security recommendations, and implements automated responses to potential security incidents. Network security is maintained through virtual network isolation, ensuring that backend services are not directly accessible from the internet, while Azure API Gateway implements additional security policies including rate limiting and request validation to prevent malicious attacks.



# Cloud Migration Strategy

(10-15 weeks estimated timeline: Deployment and implementation)

1

Phase	Focus	Est. Timeline	Key Actions	Key Outcomes	Risks and Mitigation
1	Core Platform Setup	2-3 weeks	<ul style="list-style-type: none"><li>- Deploy Azure App Service, API Gateway, Active Directory, Cosmos &amp; SQL DB</li><li>- Develop REST APIs and Logic Apps for external data polling.</li><li>- Set up Azure Functions for notifications.</li><li>- Establish university connectivity and define roles and access policies with universities.</li></ul>	Functional platform with secure login, university system connectivity, and proper role-based access.	Security misconfigurations or insufficient API protection. <i>Mitigation:</i> Conduct security reviews, endpoint testing, and thorough access control verification.
2	Recommendation Engine	3-4 weeks	<ul style="list-style-type: none"><li>- Connect Azure ML Studio to Cosmos DB for training on synthetic data.</li><li>- Develop course and job recommendation logic.</li><li>- Integrate Data Factory pipelines for external data.</li></ul>	Initial AI models trained and connected to user data pipelines.	Algorithm bias or poor performance with real data <i>Mitigation:</i> Bias detection, iterative testing, and stakeholder reviews with real or synthetic datasets.
3	Security & Storage Layer	2-3 weeks	<ul style="list-style-type: none"><li>- Configure Blob Storage, firewalls, and private endpoints for Cosmos DB.</li><li>- Enforce encryption-in-transit (TLS) and at-rest.</li><li>- Finalize secure Data Factory pipelines.</li></ul>	Encrypted data storage, secure APIs, and compliance readiness.	Misconfigured security controls or missed compliance requirements <i>Mitigation:</i> Security audits, penetration testing, and Azure Security Center integration.
4	User Testing & Feedback	3-4 weeks	<ul style="list-style-type: none"><li>- Pilot test web app (App Service) with select users.</li><li>- Collect feedback on UI/UX, recommendations, and onboarding flow.</li><li>- Monitor system metrics with Azure Monitor.</li><li>- Refine features and user experience</li></ul>	Validated feedback on usability and platform features.	Low user engagement or resistance to change. <i>Mitigation:</i> Provide training, collect early feedback, iterative design cycles, and transparent communication
5	Full Deployment & Support	Ongoing	<ul style="list-style-type: none"><li>- Enable autoscaling and performance monitoring.</li><li>- Launch user onboarding, help desk, and support processes.</li><li>- Integrate Azure Security Center for ongoing threat detection.</li></ul>	Production-ready system with scaling, monitoring, and user support.	Risk: Unexpected high load or user support issues <i>Mitigation:</i> Conduct load testing, train support staff, establish clear support processes and continuous feedback.

# Deployment Strategy - Phased Approach

(10-15 weeks estimated timeline)

1

- **Phase 1:** Foundation Infrastructure establishes core Azure services including resource groups, virtual networks, Azure Active Directory integration, and security configurations. Key tasks include creating subscription structure, implementing governance policies, and establishing monitoring baselines through Azure Monitor and Security Center.
- **Phase 2:** Data Layer Deployment sets up Azure SQL databases, Cosmos Database, and Blob Storage with appropriate security configurations. This phase implements database schemas, backup procedures, and data encryption policies. Primary risk involves data migration from existing systems, mitigated through staging environment testing and rollback procedures.
- **Phase 3:** Application and API Layer deploys Azure App Service with auto-scaling and Azure API Gateway with traffic management policies. Tasks include SSL certificate setup, load balancing configuration, and health check implementation. Downtime risks during system cutover are mitigated through blue-green deployment strategies and comprehensive testing.
- **Phase 4:** Intelligence and Integration Layer implements Azure Machine Learning Studio with trained models, Azure Data Factory for ETL operations, and Logic Apps for data synchronization. This phase validates ML performance and tests integration workflows. Model accuracy risks in production are mitigated through A/B testing and gradual recommendation rollout.
- **Phase 5:** Automation and Optimization implements Azure Functions, optimizes auto-scaling parameters, and fine-tunes security policies. This phase establishes comprehensive monitoring dashboards, automated alerting, and cost optimization through resource right-sizing. Ongoing support includes continuous user experience monitoring via Application Insights, feedback collection mechanisms, regular performance baseline reviews, capacity planning, and continuous ML model refinement based on user interaction data.



# Deployment Strategy - Tools

2

The deployment strategy leverages Azure DevOps as the primary platform for continuous integration and continuous deployment, providing integrated source control, build automation, and release management capabilities.

**Azure Resource Manager (ARM)** templates serve as the infrastructure-as-code foundation, defining all Azure resources in declarative JSON format to ensure consistent and repeatable deployments across environments.

**Jira** provides project management and issue-tracking capabilities for coordinating deployment tasks and managing change requests throughout the deployment lifecycle.

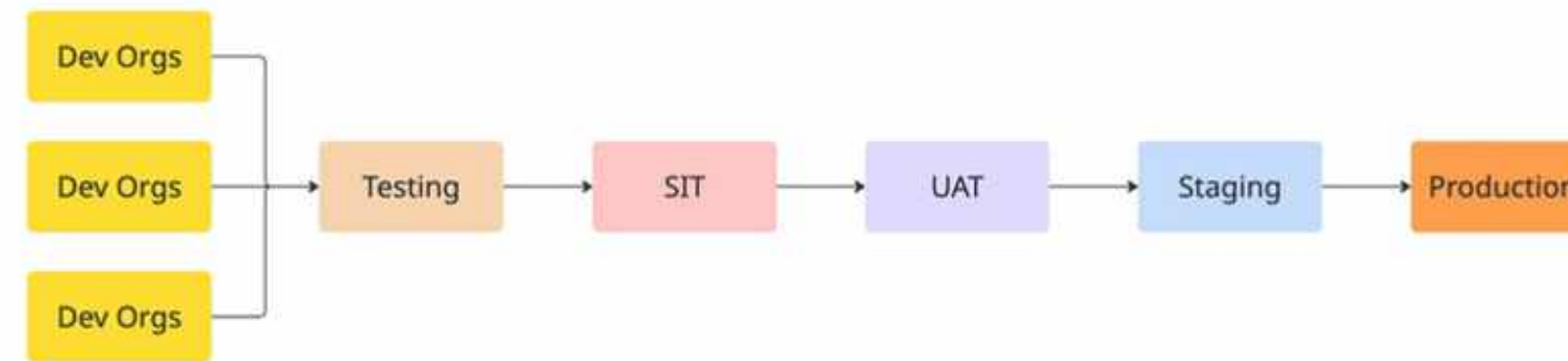
**Confluence** serves as the centralized documentation platform for maintaining deployment procedures, architectural decisions, and operational runbooks.

**Azure Policy** enforcement ensures that all deployed resources comply with organizational governance requirements and security standards.



# Deployment Strategy - CI/CD Pipeline

3



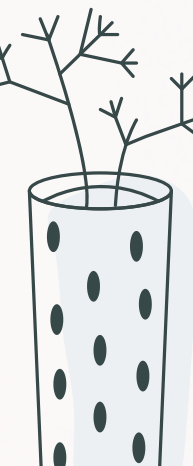
Azure DevOps Pipelines orchestrate the entire CI/CD process, automatically triggering builds when code changes are committed to source control and managing deployments across development, staging, and production environments. The pipeline includes automated testing stages that validate code quality, security compliance, and performance requirements before allowing deployment to proceed to subsequent environments.

The CI/CD pipeline implements blue-green deployment strategies for critical components, maintaining parallel production environments that allow for zero-downtime deployments and quick rollback capabilities if issues are detected. Automated testing includes unit tests for application code, integration tests for API endpoints, performance tests for auto-scaling validation, and security tests for vulnerability assessment.

Monitoring and feedback loops are built into the deployment process through Azure Monitor integration, providing real-time visibility into deployment success rates, performance metrics, and system health indicators that inform future deployment decisions and optimization efforts.

4

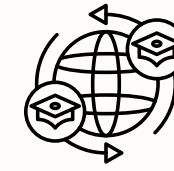
## Effects on Organizational Structure





## IT Department Operations and Personnel

- **Shift in Core Responsibilities:** The IT department will transition from managing on-prem hardware to overseeing Azure-based services like App Services, SQL Databases, and ML pipelines.
- **DevOps & Automation:** Infrastructure-as-Code (IaC), CI/CD pipelines, and auto-scaling environments will become part of daily IT ops, reducing manual deployments and accelerating iterations.
- **New Skill Requirements:** Staff will need reskilling in Azure cloud services, security, compliance frameworks, and observability tools (e.g., Azure Monitor, Log Analytics).
- **Data Governance and Policy:** With AI-driven tools handling student records, IT must enforce data residency rules (e.g., FERPA) and ensure role-based access via Azure Active Directory.



## Other Teams in the Organization

- **Academic Advising Teams:** Will benefit from SmartEd's predictive course and career suggestions, shifting their focus from reactive guidance to strategic mentoring.
- **Registrar and Curriculum Planners:** Will gain insights into course demand and performance trends, helping align offerings with student needs and industry pathways.
- **Data and AI Teams:** Will work closely with IT to monitor SmartEd's ML models and incorporate feedback loops for continuous learning and recommendation optimization.
- **Leadership & Strategy:** Will use system analytics to understand student progression patterns, identify at-risk segments, and make data-informed policy decisions.



# Changes to Help the Technical Support Organization Align with the Strategy

**New Roles & Tools**

Support teams will use tools like Azure Application Insights, Logic Apps, and chatbot frameworks to monitor uptime, performance, and handle queries.

**Compliance Training**

Support staff must be trained on handling sensitive academic data (FERPA), incident tracking, and secure access logging via Azure Security Center.



**Automation & Proactive Resolution**

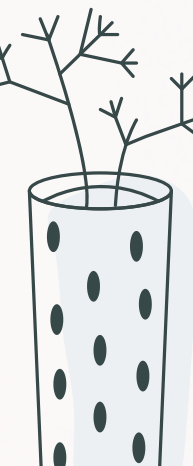
Predictive alerts will replace reactive troubleshooting, improving resolution times and user experience.

**Support Model Evolution**

Transition from generalist support to specialised tiers (e.g., Cloud Support Analysts, DevSecOps Engineers) with clear escalation paths

5

## Regulations and Compliances





# Key Compliance Requirements for UW

- **FERPA (Family Educational Rights and Privacy Act):** The most critical regulation for US universities. It protects student academic records and mandates strict control over who can access and manage student information. Any cloud system must support role-based access, audit logs, and secure storage.
- **HIPAA (Health Insurance Portability and Accountability Act):** Relevant for institutions that manage student health, counseling, or medical data. Cloud services used for such purposes must ensure encrypted transmission and HIPAA-compliant infrastructure.
- **GLBA (Gramm-Leach-Bliley Act):** Applies when institutions process financial aid or tuition payments. Requires secure handling of non-public financial information. Azure provides GLBA compliance support through network isolation, encryption, and IAM controls.
- **State-Level Data Privacy Laws (e.g., Washington State):** Washington's data breach notification and privacy laws require rapid response mechanisms and secure data handling—both achievable using Azure Security Center, Defender for Cloud, and Azure Policy.
- **Accessibility Regulations (ADA Section 508):** Any cloud-based academic tool must also be accessible to students with disabilities, following Section 508 standards for digital content and interfaces.



## Is This a Blocker to Cloud Migration?

Cloud platforms like Microsoft Azure are already compliant with US federal and state regulations, including:

- FERPA
- HIPAA (for Healthcare workloads)
- SOC 2, ISO 27001, FedRAMP, CJIS (for government data)

Azure also offers:

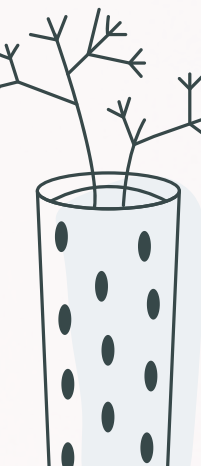
- US-based data centres to support data sovereignty
- Built-in encryption, multi-factor authentication, and zero-trust architecture
- Compliance Manager to assess and track ongoing regulatory posture

With proper configuration and institutional oversight, migrating to Azure is not only possible but can enhance compliance posture through automation, monitoring, and centralized policy enforcement.



6

## Limitations and Future Work



# Bottlenecks and Limitations

## Security Misconfigurations

Risk of exposed APIs, insufficient access controls during integration with Canvas, MyPlan



## Algorithm Bias and Accuracy

Early-stage recommendation models may underperform with real data or amplify bias in suggestions.



## Compliance & Data Residency

Ensuring FERPA adherence across cloud components and multi-tenant environments.



## Limited Initial Scope

Currently scoped for UW systems; expanding to other institutions may require custom configurations.



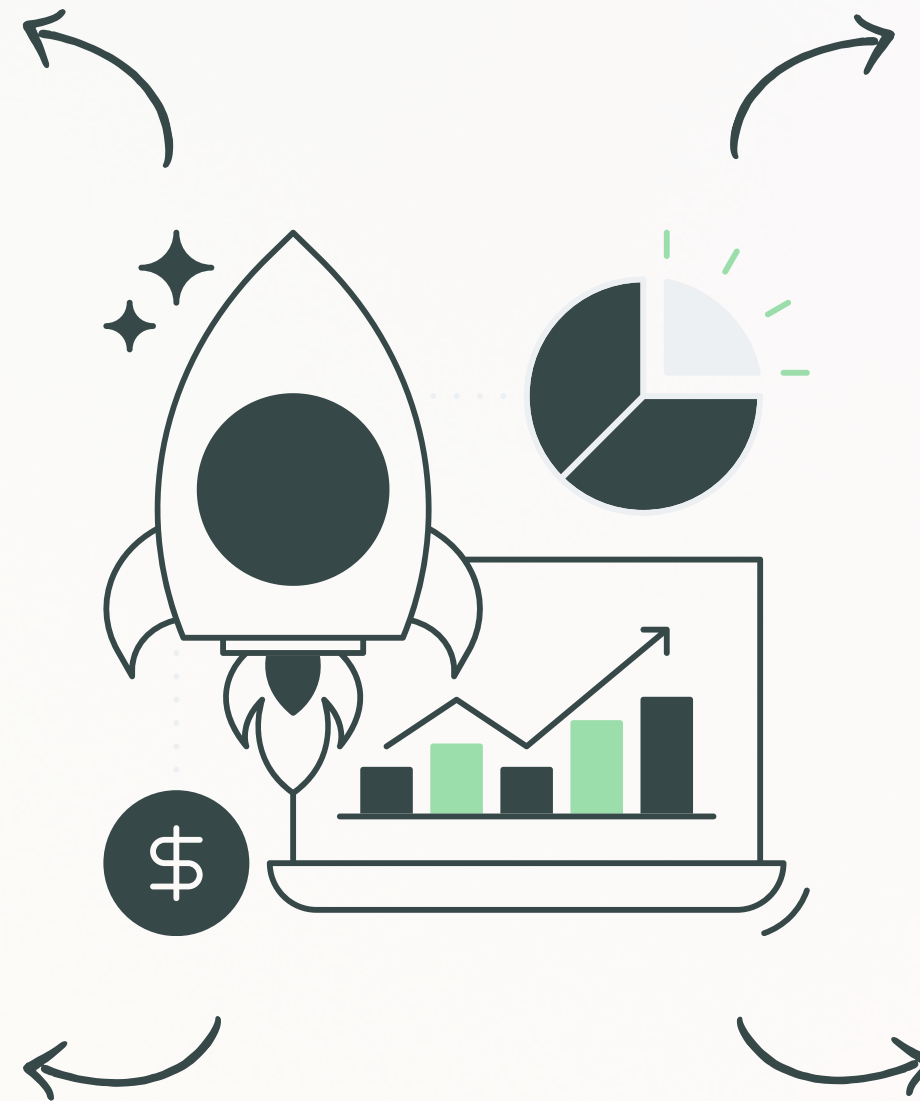
## Integration Complexity

REST API-based integration across siloed systems can face inconsistent data formats or version mismatches.



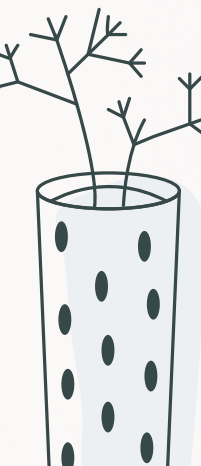
## User Adoption Risk

Resistance from faculty or students due to new workflows or lack of trust in AI outputs.



# Future work and Possible Extensions

- **Cross-Institution Expansion:** Adapt SmartED to support other universities, incorporating their academic systems.
- **Hybrid/Multi-Cloud Models:** Explore multi-cloud deployments to address regional compliance, disaster recovery, and vendor lock-in.
- **Mobile Application:** Extend functionality to a native mobile app for on-the-go planning and notifications.
- **Advanced Analytics Dashboard:** Build out dashboards for university leadership to assess engagement, performance, and market alignment.
- **Enhanced Faculty Tools:** Develop AI-powered grading assistance and syllabus generators.
- **Bias Mitigation Research:** Integrate bias detection and fairness auditing into ML models.





# References

- Khan, F. (2025). Introduction to Cloud Computing [PowerPoint slides]. IMT 589: Cloud Computing and AI, University of Washington.
- Khan, F., & Anderson, J. M. (n.d.). Digital transformation using emerging technologies: A CxO's guide to transform your organization (Kindle ed.). Amazon Kindle Direct Publishing.
- Microsoft. (2024). Microsoft Azure architecture and services overview. Microsoft Learn. <https://learn.microsoft.com/en-us/azure/architecture/>
- U.S. Department of Education. (2022). Protecting student privacy while using online educational services. <https://studentprivacy.ed.gov/>
- U.S. Department of Health and Human Services. (2023). Guidance on HIPAA & cloud computing. <https://www.hhs.gov/hipaa/for-professionals/special-topics/cloud-computing/index.html>
- Microsoft. (2024). Azure compliance documentation. Microsoft Trust Center. <https://learn.microsoft.com/en-us/azure/compliance/>
- Microsoft. (2024). What is Azure Machine Learning? Microsoft Learn. <https://learn.microsoft.com/en-us/azure/machine-learning/>
- University of Washington IT Services. (2024). UW cloud strategy and transformation initiatives. <https://it.uw.edu/initiatives/uw-it-cloud-strategy/>
- Gartner. (2023). Top strategic technology trends in higher education. <https://www.gartner.com/en>
- WSO2. (n.d.). Connected education reference architecture. <https://wso2.com/whitepapers/connected-education-reference-architecture/>
- Khan, M. A., Zhang, Y., Kumar, R., Sharif, A., Jalil, Z., & Sher, A. (2023). Cloud computing: A review of enabling technologies and future challenges. Computer Systems Science and Engineering, 36(1), 27–44. <https://www.techscience.com/csse/v36n1/40898/html>
- Polcode. (2023, May 10). How to plan software architecture for e-learning platforms. <https://polcode.com/resources/blog/how-to-plan-software-architecture-for-e-learning-platforms/>