# 🎓 EduFlow AI - Implementation Plan

## Adapting YouPac AI Architecture with SOLID Principles

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## 🎯 Executive Summary

### What We're Building

A cloud-based AI study companion that transforms course materials (PDFs, slides, videos) into structured study resources (notes, flashcards, quizzes, slides) using specialized AI agents.

### Key Inspiration from YouPac AI

- **Infinite Canvas UX**: Spatial organization of AI agents and outputs
- **Agent-Based Architecture**: Specialized AI workers for different tasks
- **Real-time Processing**: Async job queue with progress indicators
- **Export Pipeline**: Multi-format output generation

### Our Unique Approach

- **Educational Focus**: Course material ingestion + Canvas LMS sync
- **SOLID Architecture**: Clean separation of concerns, DI, ISP
- **Multiple AI Providers**: Gemini (primary), OpenRouter (fallback)

- **Self-Hosted Whisper**: Cost-effective transcription on Digital Ocean

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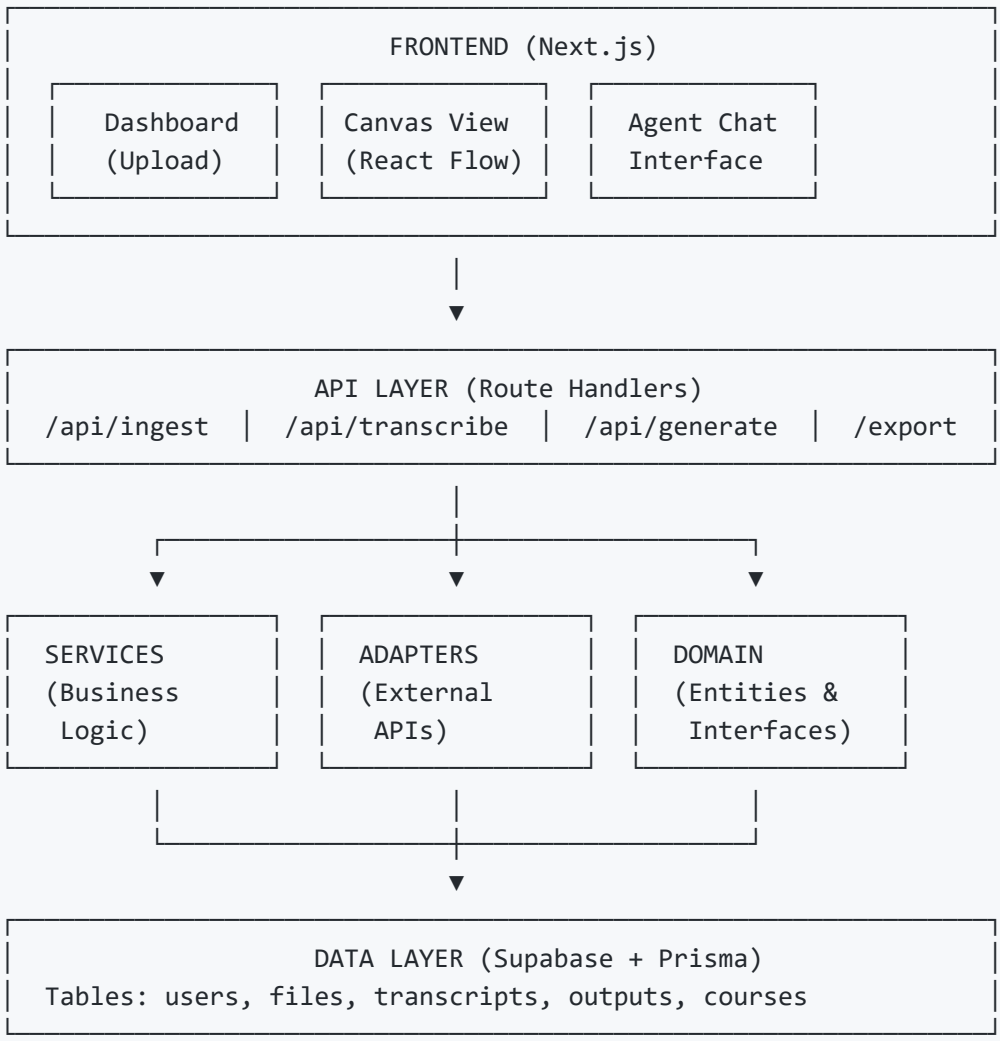
## 🏗️ Architecture Overview

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## 🎨 SOLID Principles Application

### 1️⃣ Single Responsibility Principle (SRP)

**Each class/module has ONE reason to change**

```
// ❌ BAD: God class doing everything
class AIService {
  uploadFile() { }
  transcribeVideo() { }
  generateNotes() { }
  exportPDF() { }
}

// ☑ GOOD: Separate services
class IngestService { processUpload() { } }
class TranscribeService { transcribeAudio() { } }
class GenerateService { generateContent() { } }
class ExportService { exportToPDF() { } }
```

## 2 Open/Closed Principle (OCP)

**Open for extension, closed for modification**

```
// Base agent interface
interface IAgent {
  name: string;
  process(input: ProcessInput): Promise<ProcessOutput>;
}

// Extend without modifying existing code
class NotesAgent implements IAgent { }
class FlashcardAgent implements IAgent { }
class QuizAgent implements IAgent { }
class SlidesAgent implements IAgent { }
```

## 3 Liskov Substitution Principle (LSP)

**Subtypes must be substitutable for their base types**

```typescript
// Any IModelClient can be swapped
interface IModelClient {
  complete(prompt: string, options?: CompletionOptions): Promise<string>;
}

class GeminiClient implements IModelClient { }
class OpenRouterClient implements IModelClient { }
class ClaudeClient implements IModelClient { }

// Usage - can swap clients without breaking code
function processWithAI(client: IModelClient, prompt: string) {
  return client.complete(prompt);
}
```

## 4️⃣ Interface Segregation Principle (ISP)

**Clients shouldn't depend on interfaces they don't use**

```typescript
// ❌ BAD: Fat interface
interface IAgent {
  generateNotes(): Promise<string>;
  generateFlashcards(): Promise<Flashcard[]>;
  generateQuiz(): Promise<Quiz>;
  generateSlides(): Promise<Slide[]>;
}

// ☑️ GOOD: Segregated interfaces
interface INotesGenerator {
  generateNotes(): Promise<string>;
}

interface IFlashcardGenerator {
  generateFlashcards(): Promise<Flashcard[]>;
}

interface IQuizGenerator {
  generateQuiz(): Promise<Quiz>;
}
```

## 5️⃣ Dependency Inversion Principle (DIP)

**Depend on abstractions, not concretions**

```
// ❌ BAD: Direct dependency
class GenerateService {
  private gemini = new GeminiClient(); // Tight coupling
}

// ☑ GOOD: Dependency injection
class GenerateService {
  constructor(private modelClient: IModelClient) { }
}

// Inject at runtime
const geminiClient = new GeminiClient(process.env.GEMINI_API_KEY);
const service = new GenerateService(geminiClient);
```

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## 🗓 Phase-by-Phase Implementation

### Phase 1: Foundation & Setup (Days 1-2)

**Goal**: Set up project infrastructure and core dependencies

**Tasks:**

1. **Environment Setup**
   - ☑ Create `.env.local` with all API keys
   - Install core dependencies
   - Configure TypeScript, ESLint, Prettier
2. **Database Schema (Prisma)**

```
model User {
  id        String   @id @default(cuid())
  email     String   @unique
  auth0Id   String   @unique
  courses   Course[]
  createdAt DateTime @default(now())
}

model Course {
  id        String   @id @default(cuid())
  name      String
  userId    String
  user      User     @relation(fields: [userId], references: [id])
  files     File[]
}

model File {
  id          String       @id @default(cuid())
  name        String
  type        String       // pdf, pptx, mp4, docx
  url         String
  courseId    String
  course      Course       @relation(fields: [courseId], references: [id])
  transcripts Transcript[]
  createdAt   DateTime     @default(now())
}

model Transcript {
  id        String   @id @default(cuid())
  content   String   @db.Text
  fileId    String
  file      File     @relation(fields: [fileId], references: [id])
  outputs   Output[]
  createdAt DateTime @default(now())
}

model Output {
  id           String     @id @default(cuid())
  type         String     // notes, flashcards, quiz, slides
  content      Json
  transcriptId String
  transcript   Transcript @relation(fields: [transcriptId], references: [id])
  createdAt    DateTime   @default(now())
}
```

3. **Core Domain Entities**
    - Refine existing entities (FileEntity, TranscriptEntity, OutputEntity)

- Add CourseEntity, UserEntity
- Implement value objects (FlashCard, QuizQuestion, Note)

4. **Auth0 Integration**
   - Install `@auth0/nextjs-auth0`
   - Configure protected routes
   - Create AuthProvider wrapper

**Deliverables:**

- ☑ `.env.local` configured
- Prisma schema defined
- Auth0 working on localhost
- Basic project structure validated

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## Phase 2: File Ingestion & Storage (Days 3-4)

**Goal**: Handle file uploads and text extraction

**Tasks:**

1. **UploadThing Integration**

```
// src/adapters/uploadthing.adapter.ts
import { createUploadthing } from "uploadthing/next";

const f = createUploadthing();

export const uploadRouter = {
  courseFiles: f({
    pdf: { maxFileSize: "16MB", maxFileCount: 10 },
    image: { maxFileSize: "4MB", maxFileCount: 20 },
    video: { maxFileSize: "256MB", maxFileCount: 5 },
  })
    .middleware(async ({ req }) => {
      const user = await getUser(req);
      return { userId: user.id };
    })
    .onUploadComplete(async ({ metadata, file }) => {
      await saveFileToDatabase(file, metadata.userId);
    }),
};
```

2. **Ingest Service**

```
// src/services/ingest.service.ts
export class IngestService {
  constructor(
    private supabase: IRepository,
    private textExtractor: ITextExtractor
  ) {}

  async processFile(file: FileEntity): Promise<string> {
    switch (file.type) {
      case 'pdf':
        return this.textExtractor.extractFromPDF(file.url);
      case 'pptx':
        return this.textExtractor.extractFromPPTX(file.url);
      case 'docx':
        return this.textExtractor.extractFromDOCX(file.url);
      default:
        throw new Error(`Unsupported file type: ${file.type}`);
    }
  }
}
```

3. **Text Extraction Adapters**
    - PDF: Use `pdf-parse` or `pdfjs-dist`
    - PPTX: Use `officegen` or API call
    - DOCX: Use `mammoth`

**Deliverables:**

- File upload UI component
- `/api/ingest` route handler
- Text extraction working for PDF, PPTX, DOCX
- Files saved to Supabase Storage

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## Phase 3: Whisper Transcription (Days 5-6)

**Goal**: Self-host Whisper on Digital Ocean for video transcription

**Tasks:**

1. **Digital Ocean Setup**

```
# SSH into droplet
ssh root@your-droplet-ip

# Install Python and dependencies
apt update && apt install -y python3-pip ffmpeg
pip3 install openai-whisper fastapi uvicorn python-multipart

# Create FastAPI server
# /root/whisper_server.py
```

### 2. Whisper FastAPI Server

```
from fastapi import FastAPI, File, UploadFile
import whisper
import tempfile

app = FastAPI()
model = whisper.load_model("small")

@app.post("/transcribe")
async def transcribe(file: UploadFile = File(...)):
    with tempfile.NamedTemporaryFile(delete=False) as tmp:
        tmp.write(await file.read())
        result = model.transcribe(tmp.name)
        return {"text": result["text"]}

# Run with: uvicorn whisper_server:app --host 0.0.0.0 --port 8000
```

### 3. Whisper Adapter

```
// src/adapters/whisper.adapter.ts
export class WhisperAdapter implements ITranscriber {
  constructor(private apiUrl: string) {}

  async transcribe(audioUrl: string): Promise<string> {
    const response = await fetch(audioUrl);
    const blob = await response.blob();

    const formData = new FormData();
    formData.append('file', blob);

    const result = await fetch(`${this.apiUrl}/transcribe`, {
      method: 'POST',
      body: formData,
    });

    const { text } = await result.json();
    return text;
  }
}
```

4. **Transcribe Service**

```
// src/services/transcribe.service.ts
export class TranscribeService {
  constructor(
    private transcriber: ITranscriber,
    private repository: IRepository
  ) {}

  async transcribeVideo(fileId: string): Promise<TranscriptEntity> {
    const file = await this.repository.getFile(fileId);
    const text = await this.transcriber.transcribe(file.url);
    return this.repository.saveTranscript(fileId, text);
  }
}
```

**Deliverables:**

- Whisper FastAPI server running on Digital Ocean
- `/api/transcribe` route handler
- Video transcription working end-to-end
- Progress indicators in UI

---

## Phase 4: AI Agents (Days 7-10)

**Goal**: Implement specialized AI agents using Gemini/OpenRouter

**Tasks:**

1. **Model Client Abstraction**

```
// src/domain/interfaces/IModelClient.ts
export interface CompletionOptions {
  temperature?: number;
  maxTokens?: number;
  systemPrompt?: string;
}

export interface IModelClient {
  complete(
    prompt: string,
    options?: CompletionOptions
  ): Promise<string>;
}
```

2. **Gemini Adapter**

```
// src/adapters/gemini.adapter.ts
import { GoogleGenerativeAI } from "@google/generative-ai";

export class GeminiAdapter implements IModelClient {
  private genAI: GoogleGenerativeAI;

  constructor(apiKey: string) {
    this.genAI = new GoogleGenerativeAI(apiKey);
  }

  async complete(prompt: string, options?: CompletionOptions): Promise<string> {
    const model = this.genAI.getGenerativeModel({
      model: "gemini-1.5-pro",
      systemInstruction: options?.systemPrompt,
    });

    const result = await model.generateContent(prompt);
    return result.response.text();
  }
}
```

3. **Agent Implementations**

```
// src/services/agents/NotesAgent.ts
export class NotesAgent implements IAgent {
  name = "Notes Agent";

  constructor(private modelClient: IModelClient) {}

  async process(input: { transcript: string }): Promise<string> {
    const prompt = `
      You are an expert note-taker. Transform the following lecture transcript
      into structured, comprehensive study notes using markdown format.

      Include:
      - Key concepts and definitions
      - Important examples
      - Summary sections

      Transcript:
      ${input.transcript}
    `;

    return this.modelClient.complete(prompt, {
      systemPrompt: "You are a study assistant creating organized notes.",
      temperature: 0.3,
    });
  }
}

// Similar implementations for FlashcardAgent, QuizAgent, SlidesAgent
```

4. **Generate Service Orchestration**

```
// src/services/generate.service.ts
export class GenerateService {
  private agents: Map<string, IAgent>;

  constructor(modelClient: IModelClient) {
    this.agents = new Map([
      ['notes', new NotesAgent(modelClient)],
      ['flashcards', new FlashcardAgent(modelClient)],
      ['quiz', new QuizAgent(modelClient)],
      ['slides', new SlidesAgent(modelClient)],
    ]);
  }

  async generate(
    transcriptId: string,
    type: AgentType
  ): Promise<OutputEntity> {
    const transcript = await this.repository.getTranscript(transcriptId);
    const agent = this.agents.get(type);

    if (!agent) throw new Error(`Unknown agent type: ${type}`);

    const content = await agent.process({ transcript: transcript.content });
    return this.repository.saveOutput(transcriptId, type, content);
  }

  async generateAll(transcriptId: string): Promise<OutputEntity[]> {
    const results = await Promise.allSettled(
      Array.from(this.agents.keys()).map(type =>
        this.generate(transcriptId, type as AgentType)
      )
    );

    return results
      .filter(r => r.status === 'fulfilled')
      .map(r => (r as PromiseFulfilledResult<OutputEntity>).value);
  }
}
```

### 5. Prompt Engineering

```
// src/domain/types/prompts.ts
export const AGENT_PROMPTS = {
  notes: {
    system: "You are an expert educator creating study notes.",
    template: (transcript: string) => `
      Create comprehensive study notes from this lecture transcript.
      Format using markdown with clear headings and bullet points.

      ${transcript}
    `,
  },

  flashcards: {
    system: "You are a flashcard creator following spaced repetition principles.",
    template: (transcript: string) => `
      Generate 15-20 flashcards from this content.
      Return as JSON array: [{"front": "question", "back": "answer"}]

      ${transcript}
    `,
  },

  quiz: {
    system: "You are a quiz creator making engaging assessments.",
    template: (transcript: string, difficulty: string) => `
      Create a ${difficulty} quiz with 10 multiple-choice questions.
      Return as JSON: {
        "questions": [{
          "question": "text",
          "options": ["A", "B", "C", "D"],
          "correct": 0
        }]
      }

      ${transcript}
    `,
  },

  slides: {
    system: "You are a presentation designer creating educational slides.",
    template: (transcript: string) => `
      Extract 8-12 key points for presentation slides.
      Return as JSON array: [{
        "title": "slide title",
        "bullets": ["point 1", "point 2"]
      }]

      ${transcript}
    `,
```

```
  },
};
```

**Deliverables:**

- All 4 agents implemented (Notes, Flashcards, Quiz, Slides)
- `/api/generate` route handler
- Agent chat interface for refinement
- Fallback to OpenRouter if Gemini fails

---

## Phase 5: Canvas Integration (Days 11-12)

**Goal**: Sync course files from Canvas LMS

**Tasks:**

1. **Canvas Adapter**

```typescript
// src/adapters/canvas.adapter.ts
export class CanvasAdapter {
  constructor(private baseUrl: string) {}

  async getCourses(accessToken: string): Promise<Course[]> {
    const response = await fetch(`${this.baseUrl}/courses`, {
      headers: { Authorization: `Bearer ${accessToken}` },
    });
    return response.json();
  }

  async getCourseFiles(
    courseId: string,
    accessToken: string
  ): Promise<CanvasFile[]> {
    const response = await fetch(
      `${this.baseUrl}/courses/${courseId}/files`,
      { headers: { Authorization: `Bearer ${accessToken}` } }
    );
    return response.json();
  }

  async downloadFile(fileUrl: string, accessToken: string): Promise<Blob> {
    const response = await fetch(fileUrl, {
      headers: { Authorization: `Bearer ${accessToken}` },
    });
    return response.blob();
  }
}
```

2. **Canvas Service**

```
// src/services/canvas.service.ts
export class CanvasService {
  constructor(
    private canvasAdapter: CanvasAdapter,
    private ingestService: IngestService,
    private repository: IRepository
  ) {}

  async syncCourses(userId: string, accessToken: string): Promise<void> {
    const courses = await this.canvasAdapter.getCourses(accessToken);
    const eightMonthsAgo = new Date();
    eightMonthsAgo.setMonth(eightMonthsAgo.getMonth() - 8);

    for (const course of courses) {
      if (new Date(course.created_at) < eightMonthsAgo) continue;

      const files = await this.canvasAdapter.getCourseFiles(
        course.id,
        accessToken
      );

      for (const file of files) {
        await this.downloadAndIngest(userId, course.id, file, accessToken);
      }
    }
  }
}
```

3. **Canvas UI Flow**
    - Token input modal
    - Course selection
    - File sync progress
    - Auto-generate on import

**Deliverables:**

- `/api/canvas-sync` route handler
- Canvas integration UI
- Secure token storage (encrypted in Supabase)

---

## Phase 6: Export Pipeline (Days 13-14)

**Goal**: Generate downloadable study materials

Tasks:

1. **Export Service Architecture**

```
// src/domain/interfaces/IExporter.ts
export interface IExporter {
  export(output: OutputEntity): Promise<Buffer>;
  getMimeType(): string;
  getFileExtension(): string;
}
```

2. **Exporter Implementations**

```
// src/services/exporters/PDFExporter.ts
import { jsPDF } from "jspdf";

export class PDFExporter implements IExporter {
  getMimeType() { return 'application/pdf'; }
  getFileExtension() { return '.pdf'; }

  async export(output: OutputEntity): Promise<Buffer> {
    const doc = new jsPDF();
    doc.setFont("helvetica");
    doc.setFontSize(12);
    doc.text(output.content as string, 10, 10);
    return Buffer.from(doc.output('arraybuffer'));
  }
}

// src/services/exporters/AnkiExporter.ts
import genanki from 'genanki';

export class AnkiExporter implements IExporter {
  getMimeType() { return 'application/apkg'; }
  getFileExtension() { return '.apkg'; }

  async export(output: OutputEntity): Promise<Buffer> {
    const deck = new genanki.Deck(Date.now(), 'EduFlow Flashcards');
    const model = new genanki.Model({
      name: 'Simple',
      id: Date.now(),
      flds: [{ name: 'Front' }, { name: 'Back' }],
      tmpls: [{
        name: 'Card 1',
        qfmt: '{{Front}}',
        afmt: '{{FrontSide}}<hr>{{Back}}',
      }],
    });

    const cards = output.content as Array<{ front: string; back: string }>;
    cards.forEach(card => {
      deck.addNote(new genanki.Note(model, [card.front, card.back]));
    });

    return genanki.Package(deck).writeToFile();
  }
}

// Similar for CSVExporter, PPTXExporter
```

3. **Export Service**

```
// src/services/export.service.ts
export class ExportService {
  private exporters: Map<string, IExporter>;

  constructor() {
    this.exporters = new Map([
      ['pdf', new PDFExporter()],
      ['anki', new AnkiExporter()],
      ['csv', new CSVExporter()],
      ['pptx', new PPTXExporter()],
    ]);
  }

  async export(outputId: string, format: ExportFormat): Promise<{
    buffer: Buffer;
    mimeType: string;
    filename: string;
  }> {
    const output = await this.repository.getOutput(outputId);
    const exporter = this.exporters.get(format);

    if (!exporter) throw new Error(`Unsupported format: ${format}`);

    const buffer = await exporter.export(output);
    return {
      buffer,
      mimeType: exporter.getMimeType(),
      filename:
`eduflow-${output.type}-${Date.now()}${exporter.getFileExtension()}`,
    };
  }
}
```

4. **Export API Route**

```
// src/app/api/export/route.ts
export async function POST(req: Request) {
  const { outputId, format } = await req.json();

  const exportService = new ExportService();
  const { buffer, mimeType, filename } = await exportService.export(
    outputId,
    format
  );

  return new Response(buffer, {
    headers: {
      'Content-Type': mimeType,
      'Content-Disposition': `attachment; filename="${filename}"`,
    },
  });
}
```

**Deliverables:**

- PDF export for notes
- Anki deck (.apkg) export for flashcards
- CSV export for quizzes
- PPTX export for slides
- Export UI buttons

---

## Phase 7: Frontend & Canvas UI (Days 15-18)

**Goal**: Build beautiful, intuitive UI inspired by YouPac AI

**Tasks:**

1. **Dependencies**

```
npm install @xyflow/react framer-motion lucide-react
npm install @radix-ui/react-dialog @radix-ui/react-dropdown-menu
npm install react-query @tanstack/react-query
npm install zustand # state management
```

2. **Canvas View with React Flow**

```tsx
// src/components/CanvasView.tsx
'use client';

import { ReactFlow, Node, Edge, Background } from '@xyflow/react';
import { AgentNode } from './nodes/AgentNode';
import { FileNode } from './nodes/FileNode';
import { OutputNode } from './nodes/OutputNode';

const nodeTypes = {
  agent: AgentNode,
  file: FileNode,
  output: OutputNode,
};

export function CanvasView({ courseId }: { courseId: string }) {
  const [nodes, setNodes] = useState<Node[]>([]);
  const [edges, setEdges] = useState<Edge[]>([]);

  return (
    <div className="w-full h-screen">
      <ReactFlow
        nodes={nodes}
        edges={edges}
        nodeTypes={nodeTypes}
        fitView
      >
        <Background />
      </ReactFlow>
    </div>
  );
}
```

### 3. Agent Node Component

```tsx
// src/components/nodes/AgentNode.tsx
import { Handle, Position } from '@xyflow/react';
import { motion } from 'framer-motion';

export function AgentNode({ data }: { data: AgentNodeData }) {
  return (
    <motion.div
      initial={{ scale: 0 }}
      animate={{ scale: 1 }}
      className="bg-white rounded-lg shadow-lg p-4 border-2 border-blue-500"
    >
      <Handle type="target" position={Position.Left} />
      <div className="flex items-center gap-2">
        <data.icon className="w-5 h-5" />
        <span className="font-semibold">{data.label}</span>
      </div>
      {data.status === 'processing' && (
        <div className="mt-2 w-full bg-gray-200 rounded-full h-2">
          <div className="bg-blue-500 h-2 rounded-full animate-pulse" />
        </div>
      )}
      <Handle type="source" position={Position.Right} />
    </motion.div>
  );
}
```

### 4. Agent Chat Interface

```tsx
// src/components/AgentChat.tsx
import { useAgentChat } from '@/hooks/useAgentChat';

export function AgentChat({ agentType, outputId }: Props) {
  const { messages, sendMessage, isLoading } = useAgentChat(agentType, outputId);

  return (
    <div className="flex flex-col h-full">
      <div className="flex-1 overflow-y-auto p-4 space-y-4">
        {messages.map((msg, i) => (
          <div key={i} className={`flex ${msg.role === 'user' ? 'justify-end' :
'justify-start'}`}>
            <div className={`rounded-lg p-3 max-w-md ${
              msg.role === 'user' ? 'bg-blue-500 text-white' : 'bg-gray-100'
            }`}>
              {msg.content}
            </div>
          </div>
        ))}
      </div>
      <form onSubmit={(e) => {
        e.preventDefault();
        sendMessage(e.currentTarget.message.value);
      }} className="p-4 border-t">
        <input
          name="message"
          placeholder="@Notes_Agent make this more concise..."
          className="w-full px-4 py-2 border rounded-lg"
        />
      </form>
    </div>
  );
}
```

5. **Dashboard**

```tsx
// src/app/dashboard/page.tsx
export default function Dashboard() {
  return (
    <div className="min-h-screen bg-gradient-to-br from-indigo-50 to-white">
      <header className="border-b bg-white/80 backdrop-blur">
        <div className="container mx-auto px-4 py-4 flex items-center justify-
between">
          <h1 className="text-2xl font-bold">EduFlow AI</h1>
          <UserNav />
        </div>
      </header>

      <main className="container mx-auto px-4 py-8">
        <div className="grid grid-cols-3 gap-6">
          <CourseGrid />
          <UploadZone />
          <CanvasButton />
        </div>
      </main>
    </div>
  );
}
```

**Deliverables:**

- Infinite canvas UI with React Flow
- Agent nodes with status indicators
- File upload drag-and-drop zone
- Agent chat interface
- Responsive dashboard
- Beautiful animations with Framer Motion

---

## Phase 8: Testing & Polish (Days 19-21)

**Goal**: Ensure quality, write tests, optimize performance

**Tasks:**

1. **Unit Tests**

```
// __tests__/services/generate.service.test.ts
import { GenerateService } from '@/services/generate.service';
import { MockModelClient } from '@/tests/mocks';

describe('GenerateService', () => {
  it('should generate notes from transcript', async () => {
    const mockClient = new MockModelClient();
    const service = new GenerateService(mockClient);

    const result = await service.generate('transcript-123', 'notes');

    expect(result.type).toBe('notes');
    expect(result.content).toContain('Key Concepts');
  });
});
```

2. **Integration Tests**
    - Test full flow: upload → transcribe → generate → export
    - Test Canvas sync
    - Test agent refinement chat
3. **Performance Optimization**
    - Lazy load agent nodes
    - Implement React Query caching
    - Add loading skeletons
    - Optimize Gemini API calls (batching)
4. **Error Handling**
    - Toast notifications for errors
    - Retry logic for API failures
    - Graceful degradation
5. **Documentation**
    - Update README with setup instructions
    - Add JSDoc comments
    - Create API documentation
    - Record demo video

**Deliverables:**

- 80%+ test coverage
- Error handling throughout
- Performance optimized
- Complete documentation

---

## 📦 Dependencies & Setup

### Install Command

```
npm install --save \
  @auth0/nextjs-auth0 \
  @google/generative-ai \
  @prisma/client \
  @supabase/supabase-js \
  @tanstack/react-query \
  @xyflow/react \
  framer-motion \
  lucide-react \
  uploadthing \
  @uploadthing/react \
  zustand \
  jspdf \
  genanki \
  pdf-parse \
  mammoth \
  axios

npm install --save-dev \
  prisma \
  @types/node \
  @types/react \
  @types/react-dom \
  vitest \
  @testing-library/react \
  @testing-library/jest-dom
```

### Prisma Setup

```
npx prisma init
npx prisma db push
npx prisma generate
```

### Auth0 Setup

```
openssl rand -hex 32  # Generate AUTH0_SECRET
```

---

## 🔌 API Integration Strategy

### 1. Gemini API (Primary AI)

- **Use Case**: All agent generations
- **Rate Limit**: 60 requests/minute
- **Fallback**: OpenRouter

### 2. OpenRouter (Fallback AI)

- **Use Case**: When Gemini fails/rate-limited
- **Models**: Claude 3.5, GPT-4
- **Cost**: Pay-per-token

### 3. Whisper (Self-Hosted)

- **Use Case**: Video transcription
- **Deployment**: Digital Ocean droplet
- **Model**: `whisper-small` (fast, accurate enough)

### 4. UploadThing

- **Use Case**: File uploads
- **Limit**: 2GB per upload
- **Storage**: Automatic CDN

### 5. Supabase

- **Use Case**: Database + file storage
- **Features**: Row-level security, real-time subscriptions

### 6. ElevenLabs (Future)

- **Use Case**: Text-to-speech for notes

- **Priority**: Low (add after MVP)

---

## 🎨 Frontend Architecture

### State Management

```
// src/store/useCanvasStore.ts
import { create } from 'zustand';

interface CanvasStore {
  nodes: Node[];
  edges: Edge[];
  addNode: (node: Node) => void;
  addEdge: (edge: Edge) => void;
  updateNode: (id: string, data: Partial<Node>) => void;
}

export const useCanvasStore = create<CanvasStore>((set) => ({
  nodes: [],
  edges: [],
  addNode: (node) => set((state) => ({ nodes: [...state.nodes, node] })),
  addEdge: (edge) => set((state) => ({ edges: [...state.edges, edge] })),
  updateNode: (id, data) => set((state) => ({
    nodes: state.nodes.map(n => n.id === id ? { ...n, ...data } : n),
  })),
}));
```

### React Query Setup

```tsx
// src/providers/QueryProvider.tsx
'use client';

import { QueryClient, QueryClientProvider } from '@tanstack/react-query';
import { useState } from 'react';

export function QueryProvider({ children }: { children: React.ReactNode }) {
  const [queryClient] = useState(() => new QueryClient({
    defaultOptions: {
      queries: {
        staleTime: 60 * 1000, // 1 minute
        refetchOnWindowFocus: false,
      },
    },
  }));

  return (
    <QueryClientProvider client={queryClient}>
      {children}
    </QueryClientProvider>
  );
}
```

## Custom Hooks

```tsx
// src/hooks/useGenerate.ts
import { useMutation, useQueryClient } from '@tanstack/react-query';

export function useGenerate() {
  const queryClient = useQueryClient();

  return useMutation({
    mutationFn: async ({ transcriptId, type }: GenerateInput) => {
      const res = await fetch('/api/generate', {
        method: 'POST',
        body: JSON.stringify({ transcriptId, type }),
      });
      return res.json();
    },
    onSuccess: () => {
      queryClient.invalidateQueries({ queryKey: ['outputs'] });
    },
  });
}
```

# 🧪 Testing Strategy

## Test Pyramid

```
        E2E (5%)
       /        \
      /          \
     Integration (15%)
    /              \
   /                \
  Unit Tests (80%)
```

## Tools

- **Unit**: Vitest
- **Integration**: Vitest + MSW (Mock Service Worker)
- **E2E**: Playwright
- **Coverage**: Vitest Coverage

## Example Test Suite

```typescript
// __tests__/agents/NotesAgent.test.ts
import { describe, it, expect, vi } from 'vitest';
import { NotesAgent } from '@/services/agents/NotesAgent';

describe('NotesAgent', () => {
  it('should generate structured notes', async () => {
    const mockClient = {
      complete: vi.fn().mockResolvedValue('# Key Concepts\n- Point 1'),
    };

    const agent = new NotesAgent(mockClient);
    const result = await agent.process({ transcript: 'Lorem ipsum...' });

    expect(result).toContain('# Key Concepts');
    expect(mockClient.complete).toHaveBeenCalledWith(
      expect.stringContaining('Lorem ipsum'),
      expect.any(Object)
    );
  });
});
```

# 🚀 Deployment Checklist

## Vercel Deployment

```
# Install Vercel CLI
npm i -g vercel

# Deploy
vercel --prod
```

## Environment Variables (Vercel)

Add all `.env.local` variables to Vercel dashboard.

## Database Migrations

```
npx prisma migrate deploy
```

## Whisper Server (Digital Ocean)

```
# Create systemd service for auto-restart
sudo systemctl enable whisper-api
sudo systemctl start whisper-api
```

---

# 📊 Success Metrics

## Technical Excellence

- [ ] 80%+ test coverage
- [ ] All SOLID principles demonstrated
- [ ] Zero TypeScript errors
- [ ] Lighthouse score > 90

## Feature Completeness

- [ ] All 4 agents working
- [ ] Canvas integration functional

- [ ] All export formats working
- [ ] Beautiful, responsive UI

### Demo Quality

- [ ] 3-minute demo video
- [ ] Live deployed version
- [ ] Clean GitHub repo
- [ ] Professional README

---

## 🎯 Next Steps

1. **Run setup commands**:

   ```
   npm install
   npx prisma db push
   npm run dev
   ```

2. **Set up Digital Ocean droplet** for Whisper
3. **Start with Phase 1**: Auth0 + Prisma + basic UI
4. **Iterate through phases** following this plan
5. **Test continuously** as you build

---

## 📞 Questions to Answer Before Starting

1. Do you have access to the Digital Ocean droplet?
2. Should we implement ElevenLabs now or later?
3. What's the priority: feature completeness vs. polish?
4. Do you have a Canvas account to test integration?
5. What's the hackathon deadline?

---

**Ready to build? Let's start with Phase 1!** 🚀