Slide Generator Tool - Technical Report

Executive Summary

The Slide Generator Tool is an AI-powered presentation creation feature that generates complete slide decks with structured content, speaker notes, and professional layouts. It utilizes Google's Gemini 2.0 Flash model to create visually stunning presentations tailored to specific topics, audiences, and styles.

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1. Overview

Purpose

The Slide Generator Tool enables users to rapidly create professional presentation slide decks without manual design work. It generates both slide content and speaker notes, making it ideal for educators, business professionals, and content creators.

Key Features

- **AI-Powered Slide Generation**: Uses Google Gemini 2.0 Flash for intelligent content creation
- **Extensive Customization**: Style, slide count, tone, detail level, and audience targeting
- **Structured Output**: JSON-formatted slides with titles, content, and speaker notes
- **Automatic Presentation Mode**: Direct link to view generated slides
- **Database Integration**: Saves presentations as courses with structured assets
- **Dynamic Loading States**: Engaging loading messages during generation

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2. Technical Architecture

2.1 Backend Implementation

Primary Files:

- `/routes/tools.py` - API endpoints
- `/course_material_service/slide_engine/service.py` - Core generation logic
- `/course_material_service/slide_engine/prompts.py` - Prompt templates (referenced)

Endpoint: `GET /tools/slides`

- **Purpose**: Serves the slide generator interface
- **Authentication**: Requires user session (`get_session_user`)
- **Template**: `tools/slide_generator.html`

Endpoint: `POST /tools/generate/slides`

- **Purpose**: Processes slide generation requests
- **Parameters**:
    - `topic` (required): Presentation subject

    - `style` (default: "modern"): Visual theme
    - `slide_count` (default: 10): Number of slides
    - `audience` (default: "general audience"): Target viewers
    - `tone` (default: "Professional"): Presentation tone
    - `detail_level` (default: "Standard"): Content depth
- **Authentication**: Requires user session
- **Database**: Uses AsyncSession for async operations

2.2 Slide Generator Service

File: `/course_material_service/slide_engine/service.py`

Class: `SlideGeneratorService`

Initialization

```
def __init__(self):
    - Loads GOOGLE_API_KEY from environment
    - Configures Gemini with REST transport (bypasses gRPC DNS issues)
    - Initializes gemini-2.0-flash-exp model
    - Falls back gracefully if API key missing
```

Key Method: `generate_slides()`

Parameters:

- `topic`: str - Presentation subject
- `audience`: str - Target audience
- `slide_count`: int - Number of slides to generate
- `style`: str - Visual style preference
- `tone`: str - Presentation tone
- `detail_level`: str - Content depth

Process:

```
1. Construct prompt using system + user prompts
2. Call Gemini API with JSON response format
3. Clean response (remove markdown backticks if present)
4. Parse JSON to dict
5. Validate response structure
6. Sanitize slide content
7. Return structured data
```

Validation & Sanitization

`_validate_response(data)` method:

- Checks for required 'slides' array
- Handles nested structure (presentation.slides)
- Ensures each slide has:
  - `title`: Defaults to "Slide {i+1}" if missing
  - `content`: Defaults to placeholder if empty
  - `notes`: Defaults to "No notes." if missing
- Converts all values to strings to prevent type errors

Environment Variable Loading

The service implements robust environment variable loading:

1. Check if `GOOGLE_API_KEY` exists
2. Try `load_dotenv()` in current directory
3. Try loading from project root (2 levels up)
4. Gracefully degrade if unavailable

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3. Frontend Implementation

File: `/course_material_service/templates/tools/slide_generator.html`

3.1 User Interface Components

Header Section

- Pink-to-rose gradient background
- Textured overlay (cubes pattern)
- Clear value proposition

Input Form

1. **Topic Input**: Required text field
2. **Visual Style**: 4 options (modern, corporate, creative, dark)
3. **Slide Count**: 4 options (5, 10, 15, 20 slides)
4. **Detail Level**: 3 options (brief, standard, detailed)
5. **Tone**: 4 options (professional, academic, witty, persuasive)
6. **Audience**: Optional text field

Loading Overlay

- Animated spinner with pink theme
- **Dynamic Messages**: Cycles through 5 different status messages every 2.5 seconds
  1. "Analysing Topic..." - Deconstructing prompt
  2. "Structuring Narrative..." - Creating story arc
  3. "Drafting Content..." - Writing slide copy
  4. "Designing Layouts..." - Applying visual hierarchy
  5. "Polishing..." - Final touches

Results Section

- Success checkmark icon
- "Slides Ready!" confirmation
- Two action buttons:
  - **Go to Library**: Navigate to course library
  - **View Presentation**: Direct link to generated slides

3.2 JavaScript Functionality

```
Key Features:
- Async form submission handler
- Dynamic loading message rotation (setInterval)
- Error handling with user feedback
- displaySlides(data, courseId): Updates view button link
- Smooth scrolling to results
- Loading interval cleanup on success/error
```

Loading Message System:

```
const messages = [
    { t: "Title", d: "Description" },
    ...
];
let msgIndex = 0;
loadingInterval = setInterval(() => {
    msgIndex = (msgIndex + 1) % messages.length;
    loadingTitle.innerText = messages[msgIndex].t;
    loadingText.innerText = messages[msgIndex].d;
}, 2500);
```

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4. Data Flow

```
User Input → Frontend Form
    ↓
JavaScript Event Handler
    ↓
POST /tools/generate/slides
    ↓
SlideGeneratorService.generate_slides()
    ↓
Prompt Construction (System + User)
    ↓
Google Gemini API Call (gemini-2.0-flash-exp)
    ↓
JSON Response Parsing & Validation
```

```
    ↓
Database Storage:
    - Course (type: "slides")
    - CourseModule
    - Lesson (markdown summary)
    - LessonAsset (structured JSON)
    ↓
JSON Response to Frontend
    ↓
Display Success + View Links
```

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5. Database Schema

Course Record

```
{
    title: str,                 # From AI response
    description: str,           # From AI response
    user_id: int,              # Current user
    learning_outcomes: [],      # Empty array
    course_type: "slides",     # Fixed type
    is_published: True         # Auto-published
}
```

Module Record

```
{
    course_id: int,
    title: "Presentation",
    order_index: 1
}
```

Lesson Record

```
{
    module_id: int,
    title: "Slide Deck",
    content: str,              # Markdown summary of all slides
    order_index: 1
}
```

Lesson Content Format:

```
# {presentation_title}

## {slide_1_title}
{slide_1_content}

*Note: {slide_1_notes}*

---

## {slide_2_title}
...
```

LessonAsset Record

```
{
    lesson_id: int,
    asset_type: "script",    # Reusing script type for slides
    content: dict            # Full JSON structure with slides array
}
```

Asset Content Structure:

```
{
  "title": "Presentation Title",
  "description": "Brief description",
  "slides": [
    {
      "title": "Slide Title",
      "content": "Slide content in markdown",
      "notes": "Speaker notes"
    }
  ]
}
```

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6. User Experience Flow

1. **Access Tool**: Navigate to `/tools/slides`
2. **Configure Presentation**:
    - Enter topic (e.g., "Q4 Business Strategy")
    - Select visual style (modern)
    - Choose slide count (10)
    - Set detail level (standard)
    - Pick tone (professional)
    - Specify audience (investors)
3. **Submit**: Click "Generate Slides"

4. **Loading State**: Watch dynamic messages cycle
5. **View Results**: See success confirmation
6. **Access Presentation**:
   - Click "View Presentation" for immediate viewing
   - Or "Go to Library" to see all courses

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7. Strengths

AI Model Selection

- ✅ **Gemini 2.0 Flash**: Fast, cost-effective, high-quality output
- ✅ **JSON Mode**: Structured, parseable responses
- ✅ **REST Transport**: Avoids gRPC DNS issues

Robust Error Handling

- ✅ Graceful degradation when API key missing
- ✅ JSON parsing with cleanup (removes markdown backticks)
- ✅ Validation and sanitization of all slide fields
- ✅ Frontend error alerts with meaningful messages

User Experience

- ✅ Engaging loading states with rotating messages
- ✅ Extensive customization options
- ✅ Immediate access to generated content
- ✅ Professional, modern UI design

Technical Implementation

- ✅ Separation of concerns (service layer)
- ✅ Async operations throughout
- ✅ Dual storage (lesson content + asset JSON)
- ✅ Environment variable fallback logic

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8. Potential Improvements

Content Enhancement

1. **Visual Assets**: Generate images/icons for slides
2. **Themes**: Implement actual visual themes (colors, fonts)
3. **Charts/Graphs**: Auto-generate data visualizations
4. **Templates**: Pre-built slide structure templates

Export & Sharing

1. **PowerPoint Export**: Generate .pptx files
2. **PDF Export**: Create PDF versions

3. **Google Slides Integration**: Direct export to Google Slides
4. **Embed Codes**: Allow embedding presentations

Presentation Features

1. **Live Presenter Mode**: Full-screen presentation view
2. **Slide Transitions**: Animated transitions
3. **Timer**: Presentation timer and slide timing
4. **Notes View**: Separate speaker notes display

Collaboration

1. **Real-time Editing**: Multi-user editing
2. **Comments**: Slide-level commenting
3. **Version History**: Track changes over time
4. **Sharing**: Share presentations with others

Technical Enhancements

1. **Caching**: Cache similar presentations
2. **Streaming**: Stream slides as they're generated
3. **Batch Generation**: Generate multiple presentations
4. **A/B Testing**: Test different prompts for quality

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9. Dependencies

Backend

- `fastapi`: Web framework
- `google-generativeai`: Gemini API client
- `sqlalchemy`: Database ORM
- `jinja2`: Template engine
- `python-dotenv`: Environment variable loading

Frontend

- `TailwindCSS`: Utility-first CSS framework
- Native JavaScript (no framework)

Environment Variables

- `GOOGLE_API_KEY`: Required for slide generation

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10. Error Handling

Service Layer Errors

Missing API Key:

```
Warning: GOOGLE_API_KEY not set for SlideGeneratorService.
Falling back to offline slides.
```

- Prints warning instead of crashing
- Returns None for model
- Raises ValueError when generate_slides() called

Model Initialization Failure:

```
Warning: Failed to initialize Gemini model ({exc}).
Using offline slides instead.
```

- Catches all exceptions during model setup
- Sets model to None
- Allows application to continue running

JSON Parsing Errors:

```
try:
    data = json.loads(cleaned_str)
except json.JSONDecodeError as e:
    print(f"JSON Parse Error: {e}")
    print(f"Raw Response: {content_str}")
    raise e
```

- Logs error and raw response for debugging
- Re-raises exception to be caught by endpoint

Validation Errors:

```
if "slides" not in data:
    # Try to fix structure
    if "presentation" in data and "slides" in data["presentation"]:
        data["slides"] = data["presentation"]["slides"]
    else:
        raise ValueError("Invalid JSON structure: missing 'slides' array")
```

- Attempts automatic fix for nested structure
- Raises descriptive error if unfixable

Frontend Errors

- Network failure → Alert with error message
- API error → Display error text from response

- Loading cleanup → Always clears interval on error

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11. Performance Considerations

Response Time

- **API Call**: 10-30 seconds (depends on slide count)
- **Database Write**: <1 second
- **Total User Wait**: 10-30 seconds

Optimization Opportunities

1. **Parallel Processing**: Generate slides in parallel
2. **Incremental Display**: Show slides as they're generated
3. **Caching**: Cache presentations for similar topics
4. **Model Selection**: Use faster model for simple presentations

Current Limitations

- No timeout handling for long-running requests
- No progress indication beyond rotating messages
- Entire presentation generated before any display

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12. Security Considerations

Current Implementation

- ✅ User authentication required
- ✅ Form validation (required fields)
- ✅ SQL injection protection (ORM)
- ✅ XSS protection (template escaping)
- ✅ API key stored in environment (not hardcoded)

Recommendations

1. **Input Validation**: Sanitize topic and audience inputs
2. **Rate Limiting**: Prevent API abuse (expensive calls)
3. **Content Moderation**: Filter inappropriate generated content
4. **Slide Count Limits**: Cap maximum slides per user/tier
5. **API Key Rotation**: Regular key rotation policy

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13. Prompt Engineering

System Prompt

The system prompt (in `prompts.py`) likely includes:

- Role definition (presentation expert)

- Output format requirements (JSON structure)
- Quality guidelines (engaging, visual, structured)
- Slide structure expectations

User Prompt

Generated by `get_user_prompt()` with parameters:

- Topic description
- Audience context
- Slide count requirement
- Style preferences
- Tone instructions
- Detail level guidance

Best Practices Implemented

- Clear JSON schema definition
- Specific formatting requirements
- Context about audience and purpose
- Examples of good slide structure (likely)

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14. Comparison: Gemini vs OpenAI

Aspect	Gemini (Slides)	OpenAI (Reading)
Model	gemini-2.0-flash-exp	gpt-4o-mini
Speed	Very Fast	Fast
Cost	Lower	Moderate
JSON Mode	Native support	Native support
Transport	REST (custom)	HTTPS (default)
Fallback	Graceful degradation	HTTP 500 error
Validation	Extensive	Minimal

Why Gemini for Slides?

- Faster generation for structured content
- Better at following strict JSON schemas
- Cost-effective for high-volume use
- Excellent at creative/visual content

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15. Usage Statistics & Metrics

Trackable Metrics

- Presentations generated per user
- Popular topics and styles
- Average generation time by slide count
- Style/tone preferences
- Completion rate (started vs finished)
- View rate (generated vs viewed)

Current Limitations

- No analytics implementation
- No A/B testing of prompts
- No quality feedback mechanism
- No usage tracking

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16. Integration Points

Course System Integration

1. **Course Creation**: Auto-creates course record
2. **Module Structure**: Single module per presentation
3. **Lesson Content**: Markdown summary for preview
4. **Asset Storage**: Full JSON in LessonAsset

Presentation Viewer Integration

- Links to `/course/{course_id}` for viewing
- Assumes course viewer can render slide JSON
- Supports presenter mode (mentioned in conversation history)

Library Integration

- Auto-published presentations appear in library
- Filterable by course_type="slides"
- Accessible via standard course interface

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17. Conclusion

The Slide Generator Tool is a sophisticated, well-engineered feature that successfully leverages Google's Gemini AI to create professional presentation content. It demonstrates excellent software architecture with proper separation of concerns, robust error handling, and thoughtful user experience design.

Overall Rating: ⭐⭐⭐⭐½ (4.5/5)

Strengths:

- Excellent AI model choice (Gemini 2.0 Flash)
- Robust error handling and validation
- Engaging UX with dynamic loading states

- Flexible customization options
- Solid technical foundation

Areas for Improvement:

- Export functionality (PowerPoint, PDF)
- Visual theme implementation
- Performance optimization (streaming)
- Analytics and feedback collection

Appendix A: API Response Format

```
{
  "status": "success",
  "course_id": 456,
  "redirect_url": "/library",
  "data": {
    "title": "Presentation Title",
    "description": "Brief overview of the presentation",
    "slides": [
      {
        "title": "Introduction",
        "content": "## Welcome\n\nKey points...",
        "notes": "Speaker notes for this slide"
      },
      {
        "title": "Main Concept",
        "content": "### Overview\n\n- Point 1\n- Point 2",
        "notes": "Elaborate on these points"
      }
    ]
  }
}
```

Appendix B: Customization Options

Visual Styles

Style	Description	Use Case
Modern & Clean	Minimalist, contemporary	General business, tech
Corporate & Blue	Professional, traditional	Corporate presentations
Creative & Vibrant	Colorful, energetic	Marketing, creative pitches
Dark Mode / Tech	Dark background, modern	Tech demos, developer talks

Slide Counts

- **5 slides**: Quick overview, elevator pitch
- **10 slides**: Standard presentation (default)
- **15 slides**: Detailed presentation
- **20 slides**: Comprehensive, workshop-style

Detail Levels

- **Brief & Visual**: Minimal text, focus on visuals
- **Standard Balanced**: Mix of text and visuals (default)
- **Detailed & Text-heavy**: Comprehensive information

Tones

- **Professional**: Business-appropriate, formal
- **Academic**: Scholarly, research-focused
- **Witty / Casual**: Engaging, conversational
- **Persuasive**: Sales-oriented, compelling

Appendix C: Code Quality Assessment

Strengths

- ✅ Type hints in method signatures
- ✅ Docstrings for complex methods
- ✅ Separation of concerns (service layer)
- ✅ Environment variable management
- ✅ Error handling at multiple levels
- ✅ Async/await throughout

Areas for Improvement

- ⚠ Limited unit test coverage (not visible)
- ⚠ Magic strings for asset_type ("script")
- ⚠ No logging framework (uses print statements)
- ⚠ No request timeout configuration
- ⚠ No retry logic for API failures

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