Project: Minerva Guha - The Personalised Learning Companion

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1. Vision Statement

To create a secure, private, and empathetic AI-powered home tutor - Minerva Guha. This system, hosted entirely within the user's home network, will act as a personalised learning companion for children, adapting to their unique learning styles, tracking their progress against the UK curriculum, and providing parents with actionable insights to support their educational journey. Our core principles are **Privacy, Personalisation, and Proactive Support.**

2. Core Problem & Proposed Solution

Modern families face significant challenges in supporting their children's education, from the nightly "homework battles" to the difficulty in understanding modern teaching methods. Generic online tools lack personalisation and raise significant data privacy concerns.

Our solution is a **Personalised Learning Companion** that directly tackles these issues by:

- Acting as a Socratic tutor that guides rather than provides answers.
- Aligning its teaching with the UK National Curriculum.
- Developing a deep, evolving understanding of each child's strengths, weaknesses, and learning preferences.
- Providing parents with a secure "Mission Control" portal to understand and support their child's progress.

3. Why Minerva? The Value of a Specialised Model

In an era of powerful, generalist foundation models like GPT-4 and beyond, the decision to build a specialised model is a deliberate one. While large models are "oracles" with vast knowledge, Minerva's value lies in its focused expertise and deep personalisation—something a generalist model cannot achieve.

- **Deep Context over Broad Knowledge:** A generalist model knows everything in public, but it knows nothing about your child in private. It can explain photosynthesis perfectly, but it won't remember that your child struggled with the concept last week and that a story about "plant kitchens" was their 'lightbulb moment'. Minerva's power comes from its **persistent, private context**. It remembers every interaction, evolving its teaching strategy based on a deep understanding of your child's personal learning journey.
- **A Focused Tutor, Not an Unbounded Oracle:** Large models are designed to do anything—write code, draft essays, answer trivia. This boundless capability is a

weakness in a learning context, as they can inadvertently provide answers instead of guidance. Minerva is purpose-built with one goal: to teach. Its entire personality is one of a patient, Socratic guide. It is a finely-tuned instrument designed to foster understanding, not a sledgehammer of information.
- **A Virtuous Cycle of Private Personalisation:** Using a cloud-based generalist model requires sending sensitive data about your child's learning patterns to a third party. With Minerva, this data **never leaves the home**. This is not only a critical privacy advantage but also creates a virtuous feedback loop. The more your child interacts with Minerva, the better it becomes at teaching *them*. This ever-improving personalisation is used exclusively for the benefit of your children, making the tutor more effective in a way a shared, public model can never be.

In essence, a generalist model is like the world's largest public library; Minerva is the personal librarian who has read every book *with* your child and knows exactly which one they should read next.

4. Design Concept: "The Thinking Stone"

1. Core Philosophy

Inspired by the smooth, calming, and timeless quality of a river stone. The device is designed to be an object of quiet intelligence. It doesn't shout for attention with flashy screens or harsh lights. It feels natural, warm, and inviting to touch. Its purpose is to blend beautifully into a family home—on a desk, a bookshelf, or a bedside table.

2. Physical Form & Materials

- **Shape:** An organic, asymmetrical pebble shape. It's smooth and rounded with no hard edges, slightly flattened on the bottom for perfect stability. Think of a large, beautifully worn stone you'd find on a beach. This unique shape makes it feel less manufactured and more personal.
- **Size:** Substantial but not intrusive. Imagine the size of a large avocado or a small decorative gourd—easy to hold in one hand but with a reassuring weight.
- **Materials:** The "feel" is everything.
    - **Main Body:** A matte, ceramic-like polymer that is warm and pleasant to the touch. It feels premium and natural, not like cheap plastic.
    - **Base:** A contrasting ring of natural cork or a light, soft wood (like maple). This adds an element of warmth and grounds the device in natural textures.
    - **Colours:** A palette of earthy, calming tones: Sandstone White, Slate Grey, and a deep Forest Green.

3. The "Face": The Breathing Light

Instead of a distracting screen or a simple LED ring, Minerva communicates through a soft, diffused light that appears to emanate from *within* the top half of the device itself. This gives it a gentle, biological feel—a "heartbeat."

- **Listening:** A slow, gentle pulse of soft white light, as if it's taking a slow breath.

- **Thinking:** A soft, mesmerising swirl of muted colours, like deep blue and a hint of purple, barely visible beneath the surface. This shows it's processing a complex thought.
- **Speaking:** The internal light glows with a steady, calm, warm white.
- **Notification:** For things like the "Weekly Digest" being ready for parents, it might pulse a gentle, friendly green light twice.

This subtle lighting system gives Minerva a personality and indicates its status without ever being intrusive, making it feel more alive and responsive.

4. Multimodal Capabilities (Seamlessly Integrated)

The future-facing technology is designed to be almost invisible, preserving the natural aesthetic.

- **Camera:** A tiny, pinhole camera is concealed within a seamless, dark glass panel that curves with the body of the stone. When inactive, it's virtually impossible to see. A physical privacy shutter could be integrated as a subtle sliding element.
- **Microphone Array:** A series of pinprick-sized holes are arranged on the top surface, allowing for 360-degree voice capture without disrupting the smooth finish.
- **Speaker:** A high-quality audio driver is housed in the base, firing downwards. The sound reflects off the surface the device is sitting on, creating a rich, room-filling sound that isn't harsh or directional.

5. Design Integration: The Hidden Lens

1. The Core Concept: A Magical Reveal

The projector is not permanently visible. It's concealed within the stone's body and is revealed only when Minerva decides a visual aid would be truly helpful. This makes the act of showing something a deliberate and almost magical event.

2. The Mechanical Design: "The Eyelid"

- Imagine a subtle, curved seam on the upper back slope of the "Thinking Stone," a line that perfectly follows the organic contours of the device. This seam marks a hidden panel.
- When Minerva says, "It might be easier if I show you...", this panel pivots upwards with a silent, smooth motion, like a slow-opening eyelid.
- This movement reveals the compact, high-quality pico projector lens nestled within. The reveal is accompanied by a soft chime and a gentle glow from the internal "Breathing Light," signalling that a visual is coming.
- When the visual explanation is over, the "eyelid" smoothly closes, and the device returns to its serene, stony form.

3. The Smart Functionality

- **Auto-Calibration:** The projector would have built-in autofocus and automatic keystone correction. This means you don't have to fiddle with settings. No matter the

distance or angle to the wall, the image instantly becomes a perfect, sharp rectangle. It just works.
- **Content-Aware Projection:** The visuals would be minimalist and beautiful. This isn't for browsing the web. It's for displaying specific, curated content:
    - Simple, elegant diagrams.
    - Clean, animated educational videos.
    - Rotating 3D models of anything from a DNA helix to a Roman aqueduct.

4. The Experience in Action (The Magic Moments)

This feature would create unforgettable learning moments:

- **For your primary schooler:**
    - **Minerva:** "You asked how a caterpillar becomes a butterfly. It's a process called metamorphosis. Let me show you."
    - **Projection:** A beautiful, time-lapse animation of a chrysalis wiggling and a butterfly emerging is projected onto the wall next to her bed.
- **For your secondary schooler:**
    - **Minerva:** "Visualising how tectonic plates move can be difficult from a book. Let's look at a model together."
    - **Projection:** A clear, simple animation of continental drift appears on the wall above his desk, with labels appearing as Minerva explains them.
- **For the family on a Friday night:**
    - **Minerva:** "You've all been curious about the Northern Lights. Would you like to see them?"
    - **Projection:** A stunning, high-resolution video of the aurora borealis fills the living room wall, creating an immersive, shared experience.

By hiding the projector, we turn a piece of hardware into a moment of surprise and delight. It adds an incredibly powerful capability without sacrificing the calm, minimalist aesthetic of the "Thinking Stone."

6. Visual Mockup

7. Core Feature Set: The Learning Companion

The child's primary interface with the system, designed to be engaging, supportive, and effective.

- **4.1. Socratic Tutor Engine:** The model's core directive is to guide learning through questioning, never providing direct answers to homework.
- **4.2. Curriculum Awareness:** The model will be augmented with a knowledge base of the UK National Curriculum (Key Stages 2-4) and specific exam board syllabi (e.g., AQA, Edexcel) to ensure its guidance is relevant and accurate.
- **4.3. Dynamic Learning Style Adaptation:** The tutor will implicitly learn whether a child responds better to analogies and stories versus structured, logical explanations, and adapt its approach accordingly.
- **4.4. Holistic Growth Mentoring:**
    - **The "But Why?" Engine:** Provides real-world context for academic concepts (e.g., explaining how trigonometry is used in video game design).
    - **"Connect the Dots" Feature:** Links concepts across different school subjects to foster systems thinking.
- **4.5. Gamification Features:**
    - **"Learning Quest" Mode:** Frames learning sessions as goal-oriented adventures.
    - **"Teach the Tutor" Challenge:** Reverses the roles to test for true comprehension.

8. The Evolving Learning Map (The Core Memory)

The persistent memory that makes true personalisation possible. This consists of two parts:

- **5.1. The Session Diary (Long-Term Memory):** The full transcript and context of every learning session is stored in the ChromaDB vector database. This allows the LLM to recall the specifics of any past interaction.
- **5.2. The Learning Map (Working Profile):** A structured text file, updated after each session, that summarises the child's profile.

Example Structure:
- Name: Charlotte
- Year: 4
- Strengths:
  - Creative Writing: (Confidence: High)
- Areas for Development:
  - Fractions: (Confidence: Developing) Notes: The 'pizza slice' analogy was very effective.
- Preferred Learning Style: Story-based analogies.

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9. The Parents' Portal: Mission Control

A secure, local web interface hosted within Home Assistant for parental oversight and engagement.

- **6.1. The 'At-a-Glance' Dashboard:** A customisable view featuring:
    - **"Weekly Highlights" Card:** LLM-generated summary of the week's achievements.
    - **"Confidence Meters":** Visual gauges showing progress in key subjects.
    - **"Curiosity Corner":** Highlights the most insightful question the child asked that week.
- **6.2. The 'Chat with the Tutor' Q&A:** An interactive chat window for parents to ask questions about their child's progress.
    - **Example Query:** "What's the best way to support Ben with his GCSE Chemistry revision this weekend?"
    - **Example Response:** "Ben has a strong grasp of covalent bonding but is still developing confidence with ionic bonding. A review of that topic, focusing on real-world examples like table salt, would be the most beneficial."

10. Ethical Framework & Guardian Protocols

- **7.1. Data Privacy:** The system architecture is 100% local. No learning data, transcripts, or personal information ever leaves the user's home network.
- **7.2. The Socratic Oath:** The model is programmed with a core directive to foster understanding, not facilitate cheating.
- **7.3. Positive Reinforcement:** The model's communication style is relentlessly patient, encouraging, and positive.
- **7.4. Boundary Setting:** The model will politely deflect inappropriate or out-of-scope questions and guide the conversation back to learning.

11. Prototyping Roadmap: Phase 1 (MVP)

To ensure a focused build, the initial prototype will focus on proving the core personalisation loop.

- **Scope:**
    - Set up the core tech stack (PC, Ollama, Llama 3 8B, Home Assistant, ChromaDB).
    - Implement the **Evolving Learning Map** for one child and one subject (e.g., Year 4 Mathematics).
    - Build a **text-only** interface for the child's interaction. (Voice will be Phase 2).
    - Develop the **Parents' Portal** with two key features: the "Weekly Highlights" card and the "Chat with the Tutor" Q&A.
- **Success Metrics for Phase 1:**
    - The Learning Map successfully updates after each session.
    - The "Chat with the Tutor" feature accurately uses data from the Learning Map to answer parent questions.
    - The system demonstrates a noticeable adaptation in its teaching approach over 3-4 sessions on a single topic.

12. Conclusion

Project "Personalised Learning Companion" represents a significant step forward in at-home educational technology. By leveraging the power of local LLMs, we can create a truly adaptive, private, and supportive learning environment. This document outlines the vision, architecture, and feature set for a V1.0 prototype.