Introducing STEMVentor

Technology is taught in pieces. It is used as a whole.

STEMVentor Educonsulting builds hands-on technology education content for Grades 6 to 12, from a single sensor circuit to an AI tutor grounded in a knowledge graph. This document is for schools, training organizations and education partners who want to see the substance behind the idea.

THE GAP

Students meet Physical Computing, IoT, Cloud Computing, AI and Blockchain as separate subjects, often as buzzwords. Courses tend to go deep on one technology, or stay at the level of theory. The result is learners who can name the pieces but cannot join them into a working system, which is the skill real products demand.

OUR APPROACH

Three principles run through everything we have built.

1. **Breadth before depth.** Learners map the whole landscape first: from the basics of electronics and computing, networks, and programming to the advanced applied subjects including Physical Computing, IoT, AI and Blockchain, so that every new topic has somewhere to attach.

2. **Build to learn.** Every concept ends in something that works: a small circuit, a short program, a running service. The builds are small enough to finish, and they add up.

3. **Integration is the skill.** The learning paths end in systems that combine hardware, software, data and AI, because that is where understanding is tested.

STEMVentor offers six services that fit this approach. Each can be adopted on its own, and together they take learners from a first circuit to a complete working system. An institution can begin with whichever one suits its needs best.

1	**STEMVentor Technology Learning Curriculum**	A structured, modular set of 12 learning paths for Grades 6 to 12
2	**Micro-circuits: Learn Electronics by Building**	Small, practical experiments that teach one component or idea at a time
3	**Integrated Technology Projects**	Guided projects that combine components, boards and software into working systems
4	**STEMVentor Buildathon**	Several small teams each build one part of a larger working solution
5	**STEMVentor Mentor — AI LMS Framework**	An AI tutor that answers from the learning material itself, which can also be built around an institution's own content, with an advanced path in which learners build one
6	**AI Under the Hood — Experiential AI Workshop**	An in-person workshop that shows how AI applications actually work

1. STEMVentor Technology Learning Curriculum

WHAT IT IS

A structured, modular set of technology learning paths for Grades 6 to 12. Learners start with how computers and the internet work and progress, at their own pace, to AI and blockchain.

WHAT IT INCLUDES

12 learning paths across six subject areas, ordered from Beginner to Advanced, taught through lessons and quizzes. Every learning path is paired with either micro-circuits or an integrated technology project, described in sections 2 and 3. The grade ranges below are suggestions that a partner can adjust.

Learning path	What it covers	Level
How Computers and the Internet Work	Programming: how computer hardware works (CPU, binary data, operating systems), how computers connect in networks, and how the internet and the web run, with a first look at cloud computing.	Grades 6–7 (Beginner)
Learn to Code	Programming: computational thinking with algorithms and flowcharts, programming constructs, low-level and high-level languages, then Python and the tools developers use.	Grades 6–8 (Beginner)
Build Apps with Web Tech	Programming: web and mobile apps with HTML, CSS and JavaScript, then software architecture, service-oriented design with REST APIs, relational and NoSQL databases, data security and big data.	Grades 8–10 (Intermediate)
Getting Started with Microcontrollers	Physical Computing: electricity and electronics from first principles, then development boards (Arduino Uno and Nano, ESP32, Raspberry Pi Pico, STM32), power, and programming in Arduino C, MicroPython and Node-RED.	Grades 7–9 (Beginner)
Physical Computing: Sense and Control	Physical Computing: designing and assembling circuits, then sensors, controllers, input and output devices, and wired and wireless data links such as UART, SPI, I2C, Bluetooth and LoRa.	Grades 8–10 (Intermediate)
IoT and Smart Homes	IoT: components, challenges, and the protocols that connect devices (WiFi, MQTT, Matter), and how they come together in a smart home, as in the Smart Home projects in section 3.	Grades 9–11 (Advanced)
Aeronautics and Drones	Drones: principles of flight, aircraft structure, navigation and avionics, flight procedures, then drones and their control systems.	Grades 8–10 (Beginner)
The AI Landscape	AI: what AI is and how it differs from human intelligence, applications across industries, ready-made AI services, generative AI and prompt engineering, and agentic AI.	Grades 9–11 (Intermediate)
Build Your Own AI	AI: how large language models work and how to call one through an API, then embeddings, knowledge graphs and retrieval-augmented generation, and how an AI course mentor is designed, as in the Mentor in section 5.	Grades 10–12 (Advanced)
Blockchain and Distributed Ledgers	Blockchain: decentralization, transparency, immutability and traceability, transactions, blocks and consensus, applications from finance to supply chains, challenges, and the cryptography underneath.	Grades 10–12 (Advanced)
Build on the Blockchain	Blockchain: how an application is put together on Solana, covering accounts, tokens, on-chain programs, backend APIs and a web app, as in the Solana stock market in section 4.	Grades 11–12 (Advanced)
The Big Build	Several subjects together: how shipment sensors, IoT data transmission, plate recognition, a blockchain network with smart contracts, APIs and a dashboard fit together in one system, as in the Web3 supply chain challenge in section 4.	Grades 11–12 (Advanced)

Learners read, watch, assess and share. Each topic closes with a short quiz, and the projects that apply what was taught are described in sections 2 to 5.

WHAT MAKES IT DIFFERENT

Breadth comes before depth: learners map the whole technology landscape, from electricity and computers to AI and blockchain, before they specialize. Every topic closes with a quiz, and the final path combines several subjects into one system. Learners can also join a path at the point where they feel confident.

HOW AN INSTITUTION CAN USE IT

An institution can adopt all 12 learning paths, or begin with one or two paths, for example Programming and Physical Computing, and add IoT, AI, Drones or Blockchain as learners progress. Because the paths are modular, they can be fitted around an existing timetable.

2. Micro-circuits: Learn Electronics by Building

WHAT IT IS

A library of small, practical experiments that introduce electronics, components, development boards and programming. Each micro-circuit is one component, such as a sensor, a switch, a display or a radio link, wired to a board and programmed to do one clear thing. They are where the learning journey starts: before learners meet IoT, AI or blockchain, they learn the basics one piece at a time, so that every later topic has something concrete to attach to. Micro-circuits can be used on their own or alongside the learning paths.

WHAT IT INCLUDES

The micro-circuits fall into families, shown below.

Family	Projects
Sense	Learners give a board its senses. Temperature and humidity, gas, light, sound and rain sensors read the environment, while ultrasonic distance, infrared and motion (PIR) sensors detect objects and presence. Soil moisture and water level sensors measure what plants and tanks need, and IMU, vibration, load, pressure and flex sensors capture movement, force and bending. Color and RFID sensors identify things, GPS places the board on the map, and a camera lets it see.
Input	A switch, a potentiometer, a keypad and a joystick let a person tell the board what to do, and a real-time clock lets it keep track of time.
Act	A relay switches heavier loads on and off, while a motor and a servo motor turn commands into movement.
Show and signal	An RGB LED, a pushbutton and buzzer, an LCD and an OLED let the board respond with light, sound and text.
Boards	Learners program an Arduino Nano, an ESP32 and a Raspberry Pi Pico, in Arduino C and MicroPython, and see the same ideas carry across boards.
Links	Boards then learn to talk to each other, over a wire with serial and UART connections, and without one using Bluetooth, LoRa and NRF24L01 radios.
Code basics	Beside the hardware, learners write their first code in online IDEs: Hello World in HTML, CSS styling and hyperlinks, then a Rock Paper Scissors game built three times, for the web, in JavaScript and in Python.

WHAT MAKES IT DIFFERENT

Each micro-circuit does two jobs. As a lesson, it teaches one component and how to use it. As a building block, it is a working circuit and program that reappears inside larger projects, which is how a learner moves from a single sensor to a complete system. The next section shows where.

HOW AN INSTITUTION CAN USE IT

An institution can run micro-circuits as a stand-alone electronics and coding program, as a laboratory or club activity, or as the hands-on companion to the learning paths. Because each one is short and self-contained, the institution can choose the components that fit its equipment and timetable.

3. Integrated Technology Projects: from micro-circuits to systems

WHAT IT IS

Guided projects that combine individual components, circuits, boards, communication technologies and software into working systems. They suit institutions looking for more advanced, project-based learning, and they include advanced, one-of-a-kind projects that can be shaped around an institution's own learners.

WHAT IT INCLUDES

Three smart home projects, each a sequence of guided activities, the STEMVentor IoT app, and the Pilot–ATC simulator, an advanced project.

Project	Description	What it brings together
Smart Home with ESP32	A multi-board smart home in which sensor circuits report to an ESP32 gateway that publishes their data and receives commands.	Nano and Pico sensor circuits, an ESP32 gateway, LoRa and UART links between boards, WiFi and MQTT publish-subscribe
Smart Home on Arduino	A complete smart home on a single board, reading its surroundings and driving lights, sound, a relay and a servo.	One board with an LED matrix, sensors, relay, servo, LCD and clock, connected over WiFi, MQTT and Bluetooth
Smart Home with Node-RED	The smart home controlled through a dashboard, with sensor data and control signals flowing through an MQTT broker.	Nano and Pico circuits, an MQTT broker, and a Node-RED dashboard and control flows on a Raspberry Pi
STEMVentor IoT app	A mobile app that learners build and use to configure and control IoT boards from a phone, with custom on-screen controls such as a circular knob.	A cross-platform mobile app built with React Native and Expo, board configuration screens and custom controls, connected to the smart home projects
Pilot–ATC simulator	A physical pilot panel with real controls, displays and a push-to-talk button, paired with an AI air traffic controller that speaks, listens and checks what the pilot reads back and sets. The whole system joins physical computing, speech and AI.	A panel built around an Arduino Mega with real controls and displays, a Raspberry Pi 5 that runs the air traffic controller, speech recognition and voice output, and a rules engine that checks readbacks and settings

WHAT MAKES IT DIFFERENT

The three Smart Home projects show how the building blocks are reused. The Arduino version reads temperature and humidity, gas, sound, light, soil moisture, distance and motion. It drives a relay, a servo, an RGB LED, a buzzer and an LCD, and it keeps time with a real-time clock. Each of those parts first appears as its own micro-circuit.

The ESP32 and Node-RED versions use the same parts again and change only the architecture: LoRa and serial links between boards in one, an MQTT broker and a dashboard in the other. A learner therefore meets each component three times: alone, combined in one system, and recombined in a different one. That repetition is what turns a list of components into design judgment.

HOW AN INSTITUTION CAN USE IT

An institution can offer the smart home projects as stand-alone, project-based learning, as a follow-on to the micro-circuits, or as the final stage of a physical computing and IoT program. The Pilot–ATC simulator is an example of the advanced projects STEMVentor can develop with an institution. An institution interested in a project of this kind can discuss how to shape one around its own learners.

4. STEMVentor Buildathon

WHAT IT IS

A team-based build event in which several small teams each create one part of a larger working solution, and then connect the parts into a whole. It differs from a hackathon in four ways: it brings several technologies together, it uses several small teams that each own a part of the solution, it includes physical components as well as software, and it values the process as much as the result.

WHAT IT INCLUDES

Two reference challenges, each with a complete solution that has been built and tested:

Web3 supply chain

About 40 suggested hours

An advanced solution built on Blockchain and Distributed Ledger Technology (DLT), for tracking, traceability and transparency, with all code and circuits built and tested. It combines sensors and microcontrollers, an IoT platform, a data store, a REST API, analytics and AI, a blockchain network with smart contracts, and a dashboard.

Gamified Stock Market on Solana

About 25 suggested hours

A game-like stock market built on the Solana blockchain, which gives teams a second, more game-oriented blockchain challenge.

TECHNOLOGIES INVOLVED

The Web3 supply chain challenge brings these together, using free and open source tools only:

- **Blockchain and Distributed Ledger Technology** a blockchain network with smart contracts, which records each step of the supply chain in a shared ledger that cannot be quietly altered.
- **Sensors and microcontrollers** Arduino or Raspberry Pi boards with sensors and their programs, which capture what happens in the physical world.
- **IoT platform** which receives and manages the data from the devices.
- **NoSQL data store** which holds the incoming data.
- **REST API** which connects the components to one another.
- **Analytics and AI** which turn the data into insight.
- **Dashboard** which shows the result to users.
- **Cloud services** from AWS, Azure or Google Cloud.

THE EVENT RUNS IN TWO PHASES

Phase 1, together
All teams agree the technology stack (free and open source only), the architecture and design, the infrastructure (Arduino or Raspberry Pi boards, and cloud services from AWS, Azure or Google Cloud), and the development lifecycle.

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Phase 2, in parallel
Teams split into components and connect them at logical points.

WHAT MAKES IT DIFFERENT

Each participant learns how their part fits into the whole, and how to work in the agile, collaborative way real cross-functional teams do. STEMVentor provides online training for all participants, access to the learning platform, and facilitators who stay through the event to answer questions, validate decisions and help with implementation.

HOW AN INSTITUTION CAN USE IT

An institution can host a Buildathon as the close of a term or year, for example after learners have completed the learning paths that the challenge draws on. Participants source the hardware components.

5. STEMVentor Mentor — AI LMS Framework

WHAT IT IS

An AI tutor built on top of all the learning content described above. It turns the lessons, quizzes and projects of the 12 learning paths into a body of knowledge that a learner can explore, follow and question, and it answers those questions through a web chat that is grounded in the content itself, not in the open web.

WHAT IT INCLUDES

A web chat that answers from the learning content and cites its sources, a way to browse the whole technology landscape as an interactive graph, and a lesson view with a chat scoped to the lesson in hand. It also supports tutors built around an institution's own material and an advanced path in which learners build a tutor of their own, both described under how an institution can use it.

WHAT MAKES IT DIFFERENT

Grounded, not guessed. A general chatbot answers from what it absorbed in training, and it still guesses. The Mentor answers from the platform's own material: it finds the relevant lessons, checks what is related to them, and only then responds, citing its sources. Because the tutor knows which lesson a learner is in, its answers stay within what is being taught.

TECHNOLOGY OVERVIEW

How a question becomes an answer, and the technology used at each step.

1. **Content.** Lessons, quizzes and projects are written as MDX files and held in object storage under one flat structure of unique names. Technology: MDX files and object storage.
2. **Ingestion.** The content is split into passages and embedded, and the embeddings are stored in Postgres with pgvector. Technology: embeddings, Postgres with pgvector.
3. **Knowledge graph.** Topics, lessons and projects become nodes in a Neo4j graph, with "builds on" relationships derived from the content. Technology: Neo4j, with Cytoscape.js to display the graph.
4. **Retrieval.** Vector search finds the passages closest in meaning to the question, and the graph adds related and prerequisite material. Technology: pgvector vector search and Neo4j queries, run through a separate FastAPI service.
5. **Context assembly.** The retrieved material, the learner's profile and the current lesson are assembled into the prompt. Technology: the FastAPI service, which also holds learner profiles.
6. **Answer.** A language model service writes the response from that context and cites the material it used. Technology: a language model service.
7. **Chat interface.** A web chat streams the response, keeps the conversation and session, and offers guided actions alongside free text. Technology: a Next.js front end in TypeScript with Tailwind CSS and Zustand, and Auth.js sign-in with Google or an email link.

HOW AN INSTITUTION CAN USE IT

An institution can give its learners the Mentor alongside the learning paths, so that questions are answered from the lesson in front of them. The Mentor is not tied to STEMVentor's learning paths: the same pipeline can be pointed at the institution's own material, so that the tutor answers from the institution's own content, not from the open web, with learning paths shaped around its context. An institution can start with one subject or course, review how the tutor answers, and extend it over time. Advanced learners can also build a tutor of their own through Build Your Own AI, an AI learning path suggested for Grades 10 to 12 with about 40 suggested hours. It covers language models and APIs, embeddings, knowledge graphs, retrieval and grounding, and it leads to the AI Course Mentor project (about 30 suggested hours), in which learners build a simplified version of this system. The path can be offered as a stand-alone course, as a follow-on to the AI Landscape path, or as preparation for the AI Under the Hood workshop. The next phase of the Mentor ties the views together more tightly: starting a lesson from the graph, handing a lesson question over to the open chat, and reflecting a learner's progress back onto the graph.

6. AI Under the Hood — Experiential AI Workshop

WHAT IT IS

AI Under the Hood is a live, in-person workshop that shows how a trustworthy AI answer is actually built, using the working STEMVentor Mentor as the example from start to finish.

WHAT MAKES IT DIFFERENT

Most AI in education is a chatbot added to a course catalogue. It does not know what the learner is looking at, and it still guesses. The Mentor was built differently: it is grounded in a knowledge graph, so a question is answered by finding the right material, checking what is related to it, and only then responding. The workshop walks participants through that design step by step and live, so they leave understanding how such a system works and how to judge one.

WHAT IT INCLUDES: THE JOURNEY

The session follows fourteen steps, from the basics of AI to a retrieval pipeline running in front of the room. The content draws on two of the AI learning paths, The AI Landscape and Build Your Own AI.

Step	Topic	What participants learn
1	**Welcome**	Where the session is headed
2	**Human vs. AI, machine learning types, capability levels**	What makes something artificial intelligence, and why AI is not one thing but a range of abilities
3	**Industry applications**	Where AI already works quietly in everyday life, across industries they interact with
4	**Algorithms-as-a-Service**	Ready-made AI services that companies plug into their products instead of building from scratch
5	**Generative AI and prompt engineering**	How tools like ChatGPT generate answers, and how the way a question is asked changes what comes back
6	**Agentic AI: tool use and reasoning loops**	How AI moves beyond answering, taking a goal and working through several steps on its own
7	**LLMs and talking to one through an API**	What happens behind the scenes between typing a question and receiving a reply
8	**Embeddings**	How a computer learns what text means, not only which words match
9	**Knowledge graphs**	How connecting related content, like a mind map, gives AI a sense of context
10	**Graph-augmented RAG**	Shown live: finding the right information, checking what is related, and only then responding
11	**Session awareness and personalization**	How an assistant can tell what a user is working on and tailor its help
12	**Grounding, guardrails and offline-first**	How to tell an honest AI from one that makes things up, and why AI should never be the one thing a product cannot work without
13	**Open floor and live demo**	Participants ask the live system anything and see why it answers the way it does (full-day only)
14	**Closing**	How the same approach applies beyond this one platform

FORMATS

The half-day session runs four hours and covers the complete theory with one live demo. The full-day session runs eight hours and covers the same theory with two live demos, an architecture walkthrough and the open-floor session. Group size is not limited.

HOW AN INSTITUTION CAN USE IT

The workshop is offered to schools and educational organizations, and to businesses and organizations that want their people to understand AI at this level. It runs as a Learner session or as an Educator and Trainer session. The content is the same, and the framing adapts to the room.

WHAT PARTICIPANTS LEAVE WITH

- A working vocabulary of AI types and capability levels, and a picture of where AI is already applied.
- A way to decide when to use a ready-made AI service and when to build.
- An understanding of how a language model is called through an API, how embeddings capture meaning, and how a knowledge graph adds context.
- A view of retrieval-augmented generation as it happens, not only as a diagram.
- A way to judge whether an AI system is grounded or guessing, and why offline-first design matters.

An introductory session, Getting Started with AI, is available for audiences new to the subject. Details of the workshop are at stemventor.com/ai-under-the-hood.

Working together

A partnership can start at any of six points. Each offering can be adopted on its own, and an institution can combine them over time. A school might begin with the learning paths, add the workshop for its teachers, and close the year with a Buildathon.

Every engagement draws on the same material: one set of learning paths, one set of building blocks, and the systems built from them.

HOW WE CAN PARTNER

1. **Start where it suits you.** An institution can begin with the offering closest to its needs: all of the learning paths or just a few of them, a set of micro-circuits for a laboratory or club, a Buildathon to close the year, or the AI Under the Hood workshop. The workshop is a quick way to see the approach in action, for learners or for educators and trainers.

2. **Grow at your own pace.** Because the paths, circuits and projects are modular, an institution can add to what it runs as learners progress: for example IoT, AI, Drones or Blockchain paths after Programming and Physical Computing, then the integrated projects, and later the Mentor alongside the lessons.

3. **Shape it around your institution.** The Mentor can be pointed at an institution's own material, and advanced projects such as the Pilot–ATC simulator can be developed with an institution around its own learners. An institution interested in either can start with a conversation about what it has in mind.

GET IN TOUCH

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