

## W9: EDD Element C: Design/Product Specifications

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Project Name/Topic : Open STEM Project  
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Problem Statement: How do we make STEM toys more inclusive and encourage parental engagement?

Product Specification (Testable items from the requirements).

- What is the measurable or testable value for each of the requirements in product specifications?
- Each requirement will have at least one specification tied to it per team member.
- Must have at least five specifications that can be tested.
- You may have more than five if needed.
- Prioritize in order of importance.
- Specify, data driven, measurable and to the point.
- Clearly defined minimum pass/fail values are stated.
- Includes a justification or explanation for each specification.

### Fundamental Design Criteria Addressed in almost all design.

Specifications – What does it do?

**Design Specification:** Precise and explicit information about the requirements for a successful **solution** to a problem

- Form
  - Compact, modular components (~20cm base, detachable modules).
- Function
  - Moves autonomously
  - Follows color-coded paths
  - Can be reprogrammed for new tasks
- Materials
  - ABS plastic shell (recyclable)
  - Modular connectors
  - Low-voltage electronics
- Aesthetics
  - Bright, gender-neutral colors
  - Clear labeling for modules
- Ergonomics
  - Large, easy-to-handle pieces suitable for young users
- Safety and Legal Issues
  - Rounded edges
  - Low-voltage system

- Cost
  - Affordable (ideally <\$60 retail)
- Customer Needs
  - Supports STEM learning, collaboration, and creativity through experimentation

**Product (Technical) Specification:** Explicit set of requirements that must be met in order for a **product** to operate as designed

Criteria (must do):

- Retail price  $\leq$  \$40; unit cost at scale  $\leq$  \$22.
- Assembly without tools in  $\leq$  20 minutes; all connectors keyed/polarized.
- Runtime  $\geq$  45 minutes per charge; charge via 5 V USB.
- Line-following at 0.1–0.3 m/s with  $\geq$ 90% track completion on matte paper paths.
- Drop resilience from 0.8 m onto vinyl; full post-test functionality.
- Replace any one of: battery, one motor, or one sensor in  $\leq$ 10 minutes with included parts.
- Pass ASTM F963 pre-compliance checks; operating voltage  $\leq$  5 V.

Constraints (must not violate):

- BOM limited to off-the-shelf, RoHS-compliant components; plastics are ABS/PLA.
- No sharp edges; no detachable parts < small-parts cylinder for the target age group.
- PCB area  $\leq$  50×50 mm; single-sided assembly when possible to cut cost.
- Fit within 200×150×60 mm envelope for packaging optimization.

Client Involvement:

- Client stakeholders (instructor + parent panel) review price target, lesson flow, and safety checklist at design freeze; sign-off required prior to pilot build.

Features – What do end users want?

- Affordable educational value – introduces core STEM skills (mechanical, electrical, and coding concepts) at a low cost.
- Simple modular design – interchangeable parts made from inexpensive, standardized materials to reduce production cost.
- Repairable and reusable – components can be replaced individually instead of replacing the full toy
- Parent–child collaboration – easy-to-follow instructions and short build time encourage joint participation.

Constraints – What are your limiting factors in the design?

- Price ceiling (retail  $\leq$  \$80; unit cost  $\leq$  \$22).
- Safety/standards (ASTM F963,  $\leq 5$  V).
- Limited PCB size and single-side assembly to control manufacturing cost.
- Materials limited to recyclable ABS/PLA; paper-based packaging only.
- Must assemble tool-free and be repairable with kit contents.

Parameter – What are the testable features in your design?

- Retail price and verified unit cost at scale.
- Tool-free assembly time distribution (median and 90th percentile).
- Connector cycle life (pass at 50 cycles).
- Runtime under standard duty cycle ( $\geq 45$  minutes).
- Sensor accuracy (color  $\geq 90\%$ ; distance  $\leq \pm 10\%$  error).
- Drop test from 0.8 m (pass/no-damage, full function).
- Field repair time for designated parts ( $\leq 10$  minutes).