W14 Element D 7.0 & 8.0 Materials & Fabrication Research #3

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Project Name/Topic : Open STEM Project
Date: 1/31/26
Problem Statement: How can we design an affordable, gender-neutral STEM construction kit that promotes authentic inquiry-based learning and guardian-child co-play for children ages 6-13?

Material Research

- Research THREE materials that your project can be constructed from.
- Briefly describe each method
- List a minimum of 3 PROS and a minimum of 3 CONS for each method
- Proper citation is made for all research materials
- This is research only, not a material decision yet.

Fabrication Research

- Research THREE materials that your project can be constructed from.
- Briefly describe each method
- List a minimum of 3 PROS and a minimum of 3 CONS for each method
- Proper citation is made for all research materials
- This is research only, not a fabrication decision yet.

Material Research

(Each person must research a different material type)

Material Type

ABS (Acrylonitrile Butadiene Styrene) — Thermoplastic Polymer for FDM 3D Printing

Material Description- Use STEM Principles to describe the properties of the material selected.

Science: ABS is an amorphous thermoplastic known for impact resistance and improved temperature performance compared to PLA. ABS typically has a glass transition temperature around ~105°C, meaning it is less likely to soften or deform in warmer conditions than PLA (and often higher than PETG as well). Engineering: ABS is widely used in consumer products (including durable housings) because it handles impacts and repeated use well. For MOJO's rover context, ABS is a strong candidate for parts that experience mechanical stress or moderate heat exposure (motor-adjacent components, mounts, protective housings). However, ABS is more sensitive to printing conditions and is prone to warping without a controlled environment (heated bed and enclosure). Math: ABS print success and dimensional accuracy depend heavily on controlling shrinkage and warping. Designs often need allowances for fit (clearances/tolerances), especially for press-fit features and long flat surfaces that can curl during cooling. Technology: ABS commonly prints at higher nozzle and bed temperatures than PLA, and it often benefits from an enclosure to reduce rapid cooling. Many labs also require ventilation because ABS can produce noticeable odor and emissions during printing.

PROS and CONS for each Material

PROS	CONS
Higher heat resistance than PLA; less likely to soften in warm environments	More prone to warping and cracking during prints, especially on large parts or open-frame printers
Tough and impact resistant; suitable for functional parts and protective housings	Often needs a heated bed and preferably an enclosure for reliable results
Can be sanded/finished well; good surface durability for parts handled frequently	Printing may involve odor/emissions, and many classrooms require ventilation/safety controls
Better long-term durability than PLA in many practical-use scenarios	More tuning required (temperature, cooling, adhesion) than PLA; failed prints can waste time/material
Strong candidate for motor-adjacent brackets/mounts where higher temperature tolerance matters	Adhesion can be tricky (bed prep needed), and flat parts can curl if conditions aren't controlled

APA or MLA Citation

Citation:	Simplify3D. (n.d.). Ultimate materials guide: Tips for 3D printing with ABS. https://www.simplify3d.com/resources/materials-guide/abs/

Fabrication Research

(Each person must research a different material type).

Fabrication Type/Style:

Injection Molding (Plastic Injection Molding) — High-Volume Production Method for Durable Plastic Parts

Fabrication Description- Use STEM Principles to describe the properties of the material selected.

Technology: Injection molding produces parts by heating plastic pellets until molten, then injecting the material into a shaped mold cavity. After cooling, the part is ejected and the cycle repeats. This process is widely used for consistent, repeatable plastic parts in consumer products.
Engineering: Injection molding is a strong candidate for future production because it can make identical parts quickly with excellent repeatability. The tradeoff is that it requires a mold tool, so design changes become expensive and slow once the mold is made. For a classroom prototype phase (R0/R1), injection molding is generally "research-only," while 3D printing remains the

practical iteration method.
Math: The main cost driver is the upfront tooling cost (mold). That cost can be high, but per-part cost decreases rapidly as quantity increases. This means injection molding becomes cost-effective at higher volumes, while low-volume runs favor methods like 3D printing or CNC.
Science: The method relies on thermal energy to melt polymers and then controlled cooling/solidification in the mold. Cooling behavior affects shrinkage, warpage risk, and final tolerances, which is why design rules (wall thickness consistency, draft angles) matter.

PROS and CONS for each Fabrication method

PROS	CONS
Very repeatable and consistent part quality; ideal for producing identical kit parts.	High upfront tooling cost (mold creation), which is difficult to justify for early prototypes or small batches.
Low cost per part at scale once tooling is paid for	Longer lead time than printing for a new design; mold creation and production can take weeks.
Fast cycle times for high-volume production; supports mass distribution of kits.	Design changes are expensive after tooling; iteration slows down compared to prototyping methods.
Strong material options (many engineering plastics supported) and good surface finish potential.	Design constraints (draft, uniform walls, gating/ejection considerations) add complexity.
Production-ready method for a consumer product if MOJO scales beyond classroom prototypes.	Not ideal for low-run classroom builds where rapid iteration and low setup burden matter most.

APA or MLA Citation

Citation:	Protolabs. (2023, November 28). The advantages and disadvantages of injection molding. https://www.protolabs.com/resources/blog/the-advantages-and-disadvantages-of-injection-molding/ Xometry. (2022, April 29). Advantages of plastic injection molding. https://www.xometry.com/resources/injection-molding/advantages-of-plastic-injection-molding/ Xometry. (2022, March 9). Injection molding vs. extrusion: Applications and cost drivers. https://www.xometry.com/resources/injection-molding/injection-molding-vs.-extrusion/