Again From Scratch: Material Exploration Empowers Creative Learning

A material exploration toolkit that empowers learners to craft, experiment with, and understand the world of materials.

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Abstract

This study investigates the integration of materials as active elements in maker and design education through a newly developed material exploration toolkit, "Again from Scratch". The toolkit is based on constructionism, project-based learning, and experiential learning frameworks. It aims to deepen learners' engagement with materials, thereby enhancing their creativity, design sensibility, and engineering skills. This research highlights the toolkit's potential to democratize material education and foster innovative design approaches.

CCS CONCEPTS

• Education; • Interactive learning environment; • User-centered design.

Additional Keywords and Phrases: Creativity, Maker Education, Learning Technology Design, Toolkit Design, Design Thinking, Experiential Learning, Project-Based Learning, Constructionism

1 INTRODUCTION

Material properties are the foundation knowledge for both novice and experienced makers and designers (Haworth, 1966). It empowers them to select appropriate materials for their projects and explore new creative possibilities through material manipulation and the creation of composite materials. This paper presents the "Again from Scratch" toolkit, an innovative material exploration toolkit designed to enrich this foundational knowledge. By integrating experiential learning (Kolb, 2014), project-based learning (Steenhuis & Roland, 2018), and constructionism (Ackermann, 2001), the toolkit offers a structured yet flexible educational journey. It facilitates an in-depth understanding of material properties, their real-world applications, and their integration into the manufacturing processes. The toolkit not only encourages creativity and innovation but also aims to make material education accessible to a broad range of learners, thereby enhancing their design and engineering skills through hands-on, meaningful experiences.

2 BACKGROUND

During the past decade, a variety of societal factors, such as the development of new tools and technologies, have contributed to a greater acceptance and greater popularity of maker education (Blikstein, 2018). The essential theoretical perspective of maker education can be traced back to Papert's constructionism theory which emphasizes the principle of learning through direct interaction with physical objects and actively involved in making things (Ackermann, 2001). In a constructionist classroom, learners might engage in activities like building projects, digital fabrication, or programming, which is project-based and personally meaningful in the learning process. To create tangible objects, there are some foundational skills and knowledge that learners can acquire during the making process, such as making tools, making techniques, and problem-solving skills. In such learning environments, the material has been traditionally a provided object that constructionists are familiar with using as a tool.

Metcalf argues that "the material speaks" (Metcalf, 1994). He states that materials should be an active participant in making projects, instead of an intrinsic object or tool. Materials should co-participate in the entire making process (Robbins et al., 2016). Thus, makers and designers should be able to understand the materials' "needs" and put them into consideration as an essential part of their project. The possibilities of materials are explored and even subverted again and again in modern art practice. During these bold experiments, new relations between materials, concepts, and people have been discussed over time (Ingold, 2013).In art and design practice, a recent "materialist turn" has "emphasized material's aesthetic, multisensory and agentic abilities in the process of making" (Penfold, 2019). Based on these artistic explorations and the evolving understanding of materials' roles, it becomes evident that the selection and use of materials is not merely an aesthetic choice but a foundational element in shaping educational experiences for makers and designers.

The evolving discourse surrounding material roles in maker education underscores a dynamic shift from passive to active uses of materials in the creative process. This shift reflects a deeper engagement with materials beyond their traditional applications, suggesting a symbiotic relationship between makers and their materials. Such interactions not only redefine the material's role but also broaden the scope of its contribution to the educational narrative. Consequently, embracing material exploration may offer unprecedented opportunities for innovation in creative learning environments.

3 THEORETICAL FRAMEWORK

The theoretical framework of this study is grounded on three interrelated educational paradigms: constructionism, project-based learning, and experiential learning. I applied them to design this material exploration toolkit for maker and designer education. The goal is to create a learning experience that helps learners understand the world of material to foster their creativity and enhance design and engineering skills.

Papert's constructionism is the foundation of my study just like its essential role in maker education. In this study, constructionism not only advocates for learning through direct interaction with physical objects (Ackermann, 2001) but also emphasizes the role of materials as essential constructable elements that learners manipulate and even customize to express their design ideas, thereby actively constructing knowledge. The other important construction element in this study is shapes. The design may allow learners with different levels of making skills to quickly understand geometry shapes and construct design ideas through physical geometry constructing (Cheung, 2011).

In this study, project-based learning meets the design education's need for practical, hands-on experience. Project-based learning is a learner-focused approach, which involves learners in solving real-world problems to foster a better integration of theoretical knowledge and practical skills (Steenhuis & Roland, 2018).

Lastly, experiential learning, as posited by Kolb in 1984, reinforces these educational experiences by advocating an "Experiential learning cycle" that includes four points: 1. Experiencing; 2. Reflecting; 3. Generalizing; 4. Applying. This model is a loop, which has no starting point or end point. Learners can set their starting point at any of these four stages (Kolb, 2014). This feature makes experiential learning particularly effective in material education, where the iterative testing and refining of materials and designs are paramount. Learners not only learn about the materials' physical and aesthetic properties but also their impact on the user and the environment, which is important to contemporary design practices.

Together, these frameworks provide a robust educational approach, promoting a deep, immersive, and reflective engagement with materials, which is essential for nurturing insightful, innovative, and responsive design professionals.

4 PREVIOUS WORK

Before a detailed discussion about my efforts to design the material exploration tool kit, it is worthwhile to analyze the current available material exploration project.

Material Tinkering is a project that focuses on experiential learning of material within product design education (Parisi et al., 2017). The project highlights the importance of sensorial and experiential qualities of materials, proposing "Material Tinkering" as a practical and creative approach to enable students to “understand, evaluate, and design” materials not only for their technical attributes but also for their “experiential, expressive, and sensorial characteristics”.

4.1 Learner

Parisi and his colleagues’ Material Tinkering project targeted product design students to prepare them with materials knowledge, which is considered the fundamental element of product designers’ educational journey. After the case study happened in 2015, Parisi pointed out one existing challenge, which is a lack of molds for samples’ production. “These molds could be thought as versatile tools to easily personalized operating with 3D modeling software and rapid prototyping” (Parisi et al., 2017). This challenge caused the target learners to have to be skilled designers to achieve the goal of the project.

As I explained above, I believe material and design education is important for all makers and designers to build the foundation of their projects, inspire their creation, and nurture their design and engineering thinking. Therefore, this study aims to make material education more accessible for different levels of makers and designers and even learners who have no making experience to quick steps in the material exploration and design process. To achieve this goal, I craft different levels of challenges and design a customizable mold for quick prototypes.

4.2 Method

Material Tinkering project grounds on experiential learning with a material-driven design method (Karana et al., 2015). It encourages learners to tinker with materials “without project in mind”.

Compared with this project, I would like to use project-based learning accompanied by experiential learning to structure the entire learning process, because from the case study allowing materials to lead the entire way might challenge the traditional design process and thinking (Santulli et al., 2020). I would like to build a smooth connection between material exploration and the traditional design process.

5 DESIGN

In this section, I share the design of the Again from Scratch material exploration toolkit, which empowers learners to craft, experiment with, and understand the world of materials, thereby fostering creativity and enhancing their design and engineering skills. The toolkit is intended for use in spaces such as makerspaces and schools offering courses in making or design. It is essential that there be ample space for learners to work on their projects. The entire process adapts the “Experiential Learning Cycle” (Kolb, 2014). Learners will experience all four stages as a learning period. This toolkit supports their initial learning period and can potentially facilitate subsequent periods.

5.1 Experiencing

This stage sets the foundation by prioritizing experience. Material samples are provided for learners to touch, smell, and experiment with. For instance, Figure 1 displays some of the potential materials distributed to learners.

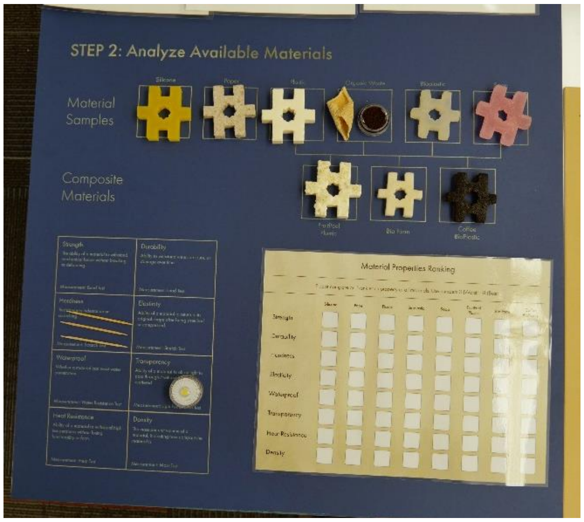

Figure 1: Nine Material Samples (From left to right: silicone, paper, plastic, organic waste, bioplastic, soap, fruit peel mix with plastic, coffee ground mix bioplastic, bio form)

To ensure learners can understand material properties from a sensorial perspective, they are required to fill out a material ranking table during this stage. This table identifies eight sensorial properties that commonly influence their utility in design and manufacturing, including strength, texture, finish, elasticity, waterproofness, transparency, heat resistance, and density (Karana, 2010). Instructions for measuring each property are provided on the left side of the ranking table to assist learners in testing and experiencing each material effectively.

The rationale for this ranking approach is rooted in comparative research methods. Learners are encouraged to compare different material samples to discern their similarities and differences. The benefits of employing comparative methods in this material-experiencing process are twofold (Esser & Vliegenthart, 2017):

1. Enhance learners' understanding of different material properties through a research-driven process.
2. Increase awareness of alternative materials, aiding learners in making strategic decisions in practice.

Figure 2: Three Challenge Proposal Samples

5.2 Reflecting

After exploring the properties of the provided samples, learners will receive different challenge proposals. Learners should reflect on these proposals, determine which material properties are required in the challenge, and pick fitting materials. All these challenges mock a real-world design challenge, which includes customers' needs, problems that need to be solved, and detailed requirements of the design (e.g., design languages, and safety requirements). By proposing these challenges, the entire learning process will be project-driven. For design education, project-based learning can help learners better integrate theoretical knowledge (they learned in previous experiencing steps) with practical design and making skills (Steenhuis & Roland, 2018), and also help them develop important skills for professional practice (Fernandes, 2014). As an example, figure 2 shows three product design challenge proposals. When applying this material exploration experience, instructors or organizations can customize those proposals to fit learners' skill levels and other sub-learning goals such as engineering skills, sustainability, and technical integration.

5.3 Thinking

After selecting the materials, learners need to design the basic shapes of the products and do quick prototyping with the selected materials. In the traditional prototyping process, learners will use paper, foam, or 3D printing to test their designs. However, these prototypes cannot reflect the realistic visual effect, structure, and manufacturing because they are not made with manufacturing materials. At the same time, the traditional prototyping process has a relatively high barrier to entry. Therefore, I designed this mold design toolkit shown in Figure 3 which includes a silicone box, various geometry bricks, and a digital design simulator. By using this kit, learners can quickly make the mold for different components of their design. For example, in Figure 4, the learners would like to have a four-leaf clover shape. They should construct the mold shapes using the bricks for further prototypes. This reverse geometry thinking will cause difficulty when learners need to do complex shapes. Therefore, the toolkit comes with a digital design simulator to help learners visualize their ideas digitally. In the app, learners can play with similar geometry bricks and the mold box. After constructing the mold, they can quickly see their designed shapes digitally from various angles before making them physically as shown in Figure 5.

5.4 Applying

After the thinking and shape design process, learners need to apply their chosen materials to the prototype. In this step, learners will receive the material-making recipes. They can choose to follow the recipes or tinker with different ingredients

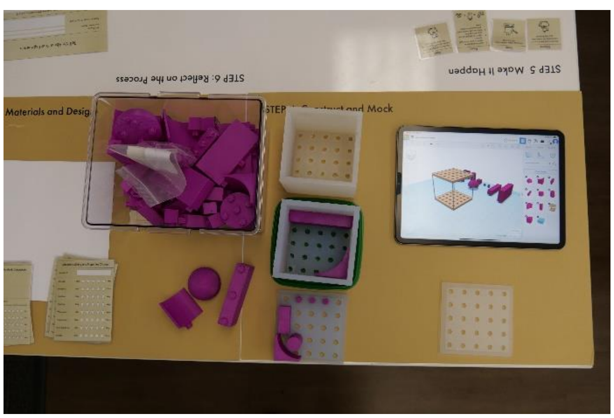

Figure 3: Mold Design Toolkit

Figure 4: Sample of learner constructing the mold to make a four-leaf clover shape

and processes. Then they can pour or press the prepared material into the designed mold to cast or shape their component prototype as shown in figure 6.

This hands-on experience complements the previous more theoretical stages. Such experience helps learners gain a deeper understanding of not only the material properties themselves but also the chemical and physical origin of those properties and realize the possibility of customizing properties. Furthermore, they can learn the procedure of material processing including but not limited to grinding, melting, and mixing. In their future design projects or further application of this toolkit, learners will be able to explore a wider range of materials or even design new composite materials.

After making the prototype with the chosen materials for personalized design, learners are able to test if the material they choose is appropriate for their design. Problems might be obvious when people can interact with the physical prototypes, for example, material A might be too fragile as the supporting structure, material B is too shiny in the using environment, and so on. By further mocking human interaction with their design, learners can gain more concrete knowledge about material properties and design.

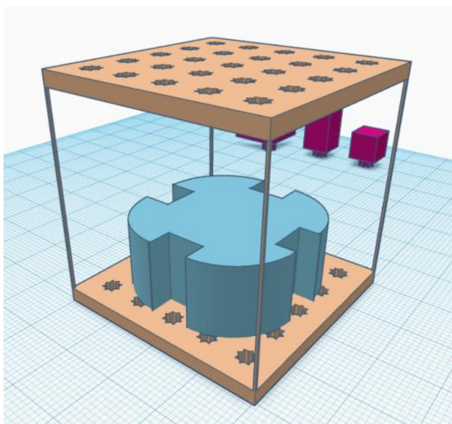

Figure 5: Visualize the shape in digital design simulator

Figure 6: Pour material into the designed mold

6 CONCLUSION

The "Again from Scratch" material exploration toolkit signifies a transformative approach in maker and design education, making the study and use of materials an active part of the learning and design process. This toolkit democratizes access to advanced material knowledge and design skills, catering not just to experienced makers but also to beginners and those with minimal making experience. This toolkit allows learners to actively engage with materials, understand their properties, and utilize them in design tasks. This contributes significantly to the community by empowering a broader audience to explore and innovate within the realms of maker education, thus nurturing a new generation of creative and capable makers, designers, and creators.

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