The design of DIY instructions for maker projects

Sruti Vijaykumar
srutiv1@umbc.edu
University of Maryland, Baltimore-County
MD

ABSTRACT

This paper is a literature review of instructions for "Do-It-Yourself" (DIY) maker projects. It studies the potential of DIY projects and the motivations of the maker community to deduce design guidelines for DIY instructions. The culture of collaborative learning, customization, and a sense of empowerment is important to the people engaged in this community. Keeping this in mind I have developed a guideline for DIY instruction design that promotes design thinking and exploration.

CCS CONCEPTS

• **Human-centered computing** → *Collaborative content creation.*

KEYWORDS

DIY instructions, maker projects, design thinking, augmented reality, passive learning, makerspaces

1 INTRODUCTION

DIY projects are a fun way of learning seemingly complicated subjects like electrical circuitry, computing, and chemistry. Along with science and technology projects, DIY projects also include skillful work like knitting, pottery, jewelry making, and glassblowing [12]. These projects are usually shared on online platforms like Instructables with a detailed set of instructions so that other people with similar interests can learn new techniques and make their own projects [7]. Makers also attend workshops and go to makerspaces to share and learn new information. Following subsections will describe a few important definitions.

1.1 DIY Projects

Do-It-Yourself (DIY) projects are projects that involve building, modifying and repairing objects yourself instead of relying on a professional or an expert [14]. People who are engaged in DIY projects are referred to as makers. The projects they make could be of personal significance like making a personalized dog collar for their dog or projects that help other people like 3D printing low-cost prosthetic limb devices for children and adults.

1.2 DIY Instructions

It is a step-by-step instruction set that guides makers in their projects. DIY instructions typically include a material list, a tools list, links to resources, pictures, descriptions and even tips on the tools used and processes followed. DIY instructions can be made by experts or by makers who have figured out techniques one their own and are used by makers who want to learn new DIY techniques[3].

1.3 Makerspaces

A Makerspace is a physical location where a maker can get access to tools and machines to help them take an idea from their mind to a physical object. It is usually a place where like-minded people come together, learn to use tools, share their ideas and collaborate on projects. The tools available in makerspaces are usually not easily available in people's homes. These tools include but are not limited to 3D printers, laser cutters, LEDs, soldering guns. There are different types of makerspaces. Some are non-profit community-based makerspaces and some makerspaces require a membership and may come with a membership fee[9].

1.4 Maker Movement

The maker movement is a social movement that democratizes science and innovation and puts the power of building objects into the hands of common people. It encourages collaboration and persistence through DIY projects that follow an iterative design process. It is about giving people confidence and a sense of pride in their creations[4].

This paper will explore topics like the maker community culture, the needs of makers and the applications of DIY projects in a quest to understand what makers expect from DIY instructions and how it can enhance their learning experience.

2 BACKGROUND AND MOTIVATION

DIY projects have many benefits. They can promote passive learning[6], increase creativity and teach perseverance and self-reliance. Children and especially young girls [8] can be encouraged to learn more about STEM-related projects. Making something from scratch is not only a good learning experience but also a confidence booster. DIY can empower people with disabilities by enabling them to customize their assistive technology devices. [5] The maker community welcomes makers of all ages, disciplines, and abilities. Makers can express their creativity, meet like-minded people and support each other. All these reasons make the maker movement a topic worth exploring. As DIY projects are mostly done in the absence of an expert, makers may not have all the knowledge they need to build their projects successfully. A step-by-step instruction set can help bridge the knowledge gap and guide makers through their projects. Instructions have a major role to play in sharing knowledge which is an integral part of the maker community. It is a primary source of knowledge transfer and should effectively represent the maker's thought process. It should also be reflective of the reader's needs and the community's culture as a whole.

I couldn't find many papers and articles dedicated to the design of DIY Instructions but I did find papers that indirectly reveal what makers are looking for in instructions. Through this literature review, I want to find answers to questions like when should a maker

start documenting, what should they include and not include in instructions and how can they structure their instructions to spark curiosity in the minds of readers.

3 LITERATURE REVIEW

3.1 Design thinking

Shroyer studies formal and informal design learning with the purpose of redesigning Do-it-yourself instructions to better support design thinking for beginning makers. She describes the design process as a series of convergent and divergent activities which is about exploring alternative design paths and choosing the path that best suits the needs and constraints of the project. There are three ways in which a beginner might engage in a new project by either going to a makerspace or a workshop or by using a DIY instruction manual at home [12].

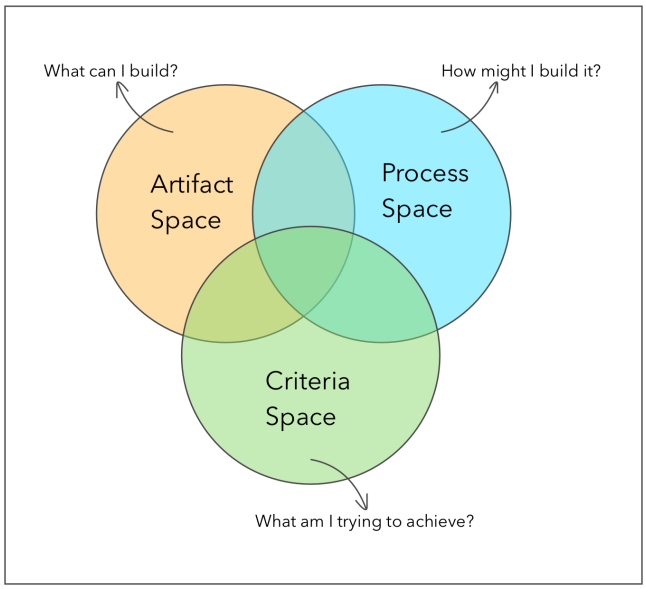

Figure 1: Visualization of the three Possibility Spaces for DIY Project[12]

Shroyer conducts three-year-long qualitative studies on makers and students involved in fabrication projects like glassblowing, electronics, physical computing, sewing, baking, laser cutting, 3D printing, and ceramics to understand design learning . She came up with three intersecting possibility spaces (See Fig. 1) that makers can choose from when engaging in DIY Projects. They are the Artifact space, Process space, and Criteria space. The paper gives some great insights into the potential of DIY instructions in stimulating design thinking but fails to give a definitive framework or a set of guidelines to achieve that[12].

3.2 Maker community culture

Kuznetsov and Paulos believe mass production of goods has discouraged the concept of self-building, modifying and repairing objects which were common in the past. The Maker Community moves away from paid goods and services and focuses on the skills of creative building. One thing that the paper states clearly is that the DIY culture is not motivated by making monetary profits. The main motivations are curiosity, passionate problem solving and self-reliance. Having fun and connecting to like-minded people are also some major motivations for this community. The maker community finds joy in collaborative learning and sharing. Using platforms like Instructables, Adafruit, Dorkbot, Ravelry, Craftser, and Etsy, makers from across the globe share and learn new techniques and ideas for their DIY projects. Some of the DIY projects shared on these platforms include electronic art, knitting, cooking, and jewelry making. The maker community is open and welcoming to people of all ages, levels of knowledge, backgrounds, and abilities. A drawback of this paper is that the survey responses were from largely from female participants working in knitting and crochet projects. This may have biased the conclusions made by the authors as the DIY community actually includes a wide variety of project types and people[7].

3.3 Needs of makers

Tseng and Resnick focus on the techniques of DIY project documentation from the perspective of two user groups; the creators of the project and the readers. They have interviewed several users of the Instructables website to understand the differences between these two user groups. They have attempted to identify the most effective methods of design documentation and its application. One participant in the study stated that he likes to combine the instructions from multiple Instructables to build projects. They realized that creators of projects focus on creating step-by-step "recipes" for the project whereas readers are looking for techniques that they can quickly learn and apply. They are not always looking to build the exact same project that creators have built but rather want to learn a new skill that they can apply in their own unique projects. This paper explores the inconsistencies between project creators' methods of documenting DIY projects and readers' methods of utilizing those documentations. Understanding this gap has helped me identify design opportunities in DIY instructions. This paper has influenced the design guideline in the discussion section of this paper[13].

Formal learning also makes use of instructions except that it is highly structured. For example, a professor giving instructions to a student for their capstone project at a University. Murphy et al. say that in formal learning, faculty members choose instructional technology that they seem fit for a course but the needs of the students who are the end-users of the instructions are not taken into account. They feel that it is important to analyze the needs of the students, define the instruction goals and choose appropriate teaching methods. They introduce the ADDIE Model and the Dick and Carey Model that break down a project into different phases that facilitate effective learning. The ADDIE model is preferred for smaller projects as it has fewer phases so It may be more appropriate for DIY projects. The phases in this model are: Analyze, Design, Develop, Implement, and Evaluate. To perform a needs analysis, the instructor needs to first do a gap analysis. They must define the objective or the desired outcome of the training, what is the current knowledge level of the student, and what is the gap between the desired outcome and the current status of the student.

By performing a KASH analysis, researchers found that students struggled with text-based instructions. Image-based instructions were helpful but too many images made it difficult to discern specific information. Targeted video tutorials were found to be the most useful. The needs analysis techniques mentioned in the paper requires the instructor to observe the students and identify the gap in the instruction method. This gap is unique to every project and identifying it can be time-consuming. DIY projects don't have the luxury of time. So this paper may not completely fit in the context of DIY instructions. People in this community want to learn and implement techniques quickly unlike formal learning which is methodical and can go on for several months[11].

3.4 Passive education for children

Lovell and Buechley think that DIY projects can be great for getting young adults interested in STEM (Science, Technology, Engineering, and Mathematics). They want to make tutorials that teach new techniques in a simple way and let children explore the possibilities of those techniques. For example, in this paper, they made an e-sewing tutorial that teaches makers the basics of circuitry and gives them the freedom to develop their own unique projects. They used illustrations, photographs, and text descriptions to make the tutorial. They conducted a pilot study with two 13-year-old girls and both children used the tutorial to create unique projects that had personal meaning attached to them. They wish to make their tutorial more engaging in the future by using video, simulation, and animations. They hope to increase the participation of girls in the field of computer science through these projects. The drawback of this paper is that the study is conducted with only two participants but nevertheless it shines a light on makers' acceptance of open-ended tutorials[8].

Kim discusses in his paper that children today use technology extensively but do not understand or even attempt to understand how it actually works. He stresses the importance of passive learning or informal learning by engaging in DIY projects. He has made a multipurpose light kit for children to set up on their own called Plus Minus. Children can express their creativity by customizing their light while learning the basics of circuitry through easy-to-understand instructions. What is interesting about the DIY kit is that it is designed to not have a short circuit. By using affordances and magnets that don't allow short circuits, the kit is designed to work no matter what. Which is good if the goal is to make the child feel accomplished but not so good if the goal is to promote learning. Children may not fully understand circuitry if they don't know which connections work and which connections don't [6].

3.5 Accessibility and DIY projects

Hurst discuss the need to encourage assistive technology users to engage in do-it-yourself projects. There are a wide range and degrees of disabilities. "Off the shelf" assistive technology devices don't fully satisfy the unique needs of each individual so they end up abandoning the devices and buying new ones which is a costly affair. Therefore, instead of buying products, people with disabilities can design and make their own assistive devices by joining the maker movement. However, this comes with its own set of challenges for people with disabilities. Machines like band saws and lathes need their users to stand for a long time, have good vision and dexterity. Computer Numeric Controlled (CNC) tools solve this issue to some extent. Examples of CNC tools are 3D printers and laser cutters. They have described two projects, VizTouch and Easy Make Oven, that make CNC tools more accessible. A problem with this paper is that the researchers have tested their projects with able-bodied students. The success of VizTouch and Easy Make Oven cannot be determined unless they test it with its intended users which is people with disabilities [5].

Meissner et al. explore the experiences of people with disabilities (PWD) involved in maker projects. They realized that there is an insufficient number of opportunities for people with disabilities to actively participate in the design of Do-it-yourself Assistive Technology (DIY-AT). So they analyzed video content, makerspaces and ran a series of maker workshops for people with disabilities. The accounts from the qualitative study uncovered interesting details about the issues, motivations, qualities, and collaboration techniques unique to this community. The researchers found that PWD have more patience than able-bodied makers. They are sensitive to each other's strengths and weaknesses and collaborate based on abilities. They also felt that making made them feel empowered and they felt good about empowering others through their projects. The paper talks about assistive devices being abandoned and how PWD can customize their assistive devices by being makers themselves. However, the projects built by the participants did not reflect that. The projects were innovative but brand new ideas. They did not focus much on modifying existing assistive technology to suit their needs better [10].

3.6 AR in DIY projects

Chiang et al. found out that the quality of instruction and level of involvement of the learner while learning influences the learner's performance greatly. They suggest using Augmented Reality (AR) for Personal Computer Do It Yourself (PC DIY) learning. They gathered data through questionnaires after asking twenty-six graduate students to interact with a prototype. They did not use head-mounted displays that are traditionally used in AR systems as they felt it would interfere with the learning experience and used projected 3D objects instead. A teacher explained the assembly of the computer system architecture using projected 3D objects. The learners first practiced the assembly using 3D objects and then assembled real hardware parts to complete the task. A drawback of this paper is that the user study only takes feedback about the user's learning experience through a survey. Having more participants and talking to user experiences may have resulted in more credible data[2].

Bosch et al. studied the effects of AR-based instructions on productivity, workload, and quality of the product. The current instruction methods used in manufacturing are paper-based or instructions displayed on an electronic screen. Thirty-five participants took part in this within-subject study. The participants in their study were given a short tutorial and then asked to manually assemble components that had AR markers. The authors have visualized data gathered from the study and come to the conclusion that AR instructions increased learners' productivity and product quality and decreased the workload as compared to instructions on a screen.

However, the paper did not talk about how accessible AR instructions are. Questions like, is it difficult to set up, is it applicable to all types of projects and all types of users are unanswered[1].

4 DISCUSSION

There is no doubt that the maker movement has had a positive impact on people's lives. Testimonials of various participants across all papers show that DIY projects have improved the quality of life of makers. They have received job opportunities and recognition from the community. It has made them confident, self-reliant, and creative. Makers feel a sense of community when they go to makerspaces, meet people with similar interests, and collaborate with them on projects. They are allowed to explore, make mistakes and learn without judgment.

DIY instructions have an important role to play in the learning experience. It has not been explicitly talked about in many papers but through this literature review, I was able to identify what aspects of DIY are important to makers and subsequently what makes an effective instruction set. The common theme across most papers was supporting self-exploration in DIY projects through instructions.

4.1 Tips from Makers on creating instructions

Instructables is popular in the maker community. Makers on Instructables encourage people to upload multiple formats of instructions and link them all with each other. Makers on this platform suggest making a video of the process, uploading it to an easily accessible platform like youtube and linking it to the written instructions. They also suggest adding many pictures, clear grammatically correct descriptions, tips on either the tools used or the process and links so people can explore topics further if they want to. Michael lawing, a maker on Instructables says that adding humor to your instructions is well received in the maker community. His most popular post was a sarcastic instructable on how to train a dog.

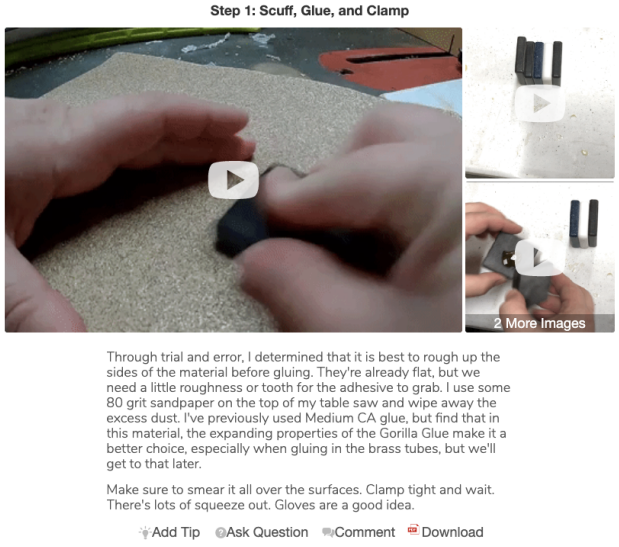

Figure 2: A screenshot of the first step of an instructable called "Segmented Corian Pen" on instructables.com

4.2 Level of Abstraction

Plus Minus, a passive circuitry learning DIY kit, is designed to not have short circuits or any other kind of failure [6]. The kids using this kit feel accomplished when they are able to set up their own light source. However, I wonder how effective the learning process will be if the kit doesn't allow failure. The maker community supports design exploration and curiosity [7]. For effective learning, knowing what doesn't work is as important as knowing what works. DIY kits should not intimidate the maker with too much complexity and at the same time, it should not limit learning with too much abstraction of information. I don't think this balance of complexity and ease-of-learning depends on age but rather on the level of expertise of the maker in that subject.

4.3 Guideline for designing DIY instructions

Creators give importance to documentation but think it often conflicts with the usability of the instructions. So in an effort to reduce the messiness, they leave out the parts that elaborately explain the design process. Their goal is efficiency and accuracy not deeper design learning. [12] However, another study by Tseng found that readers of these instructions are looking for techniques that they can learn quickly and not step-by-step instructions. They want to learn about the design decisions made at each step so that they can modify the steps to suit their constraints and strengths [13].

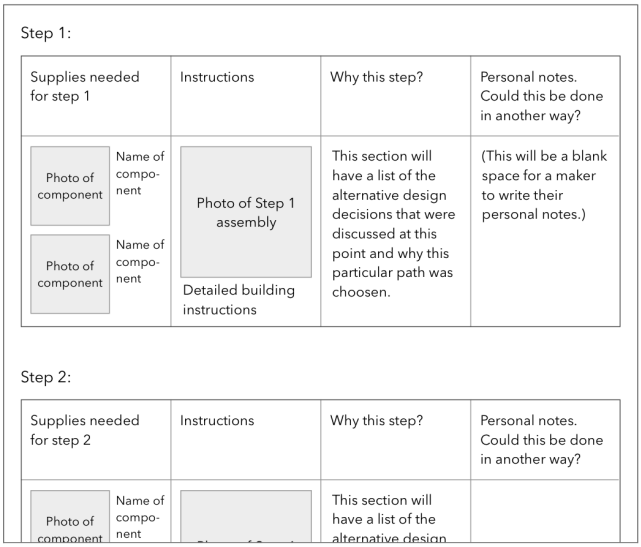

Figure 3: A guideline for designing DIY instructions that promotes design thinking.

Keeping this in mind I have made a guideline for the design of DIY instructions that will support design thinking. (See fig. 3) This guideline has four sections for each step. One section has the supplies needed for that particular step along with pictures of the component. Another section has detailed instructions and photos that show how to assemble the components. The third section discusses the thought process of the creator of the project for that particular step. And the last is a blank column for the reader to take personal notes and write down alternate paths or experimental

ideas. This easy-to-read format allows readers to pick and choose what they would like to focus on in the instruction. The intention of the third section is to give readers a sneak-peak into the project creator's mind and accelerate their own thought process. The blank column encourages readers to form and jot down their own thoughts, thus, promoting design thinking and exploration.

5 CONCLUSION

This literature review explores the potential of DIY instructions in promoting design thinking and self-empowerment. It discusses topics like design thinking, needs of makers, applications of DIY projects and the use of Augmented reality to make instructions interesting and engaging. Instructions are the medium through which people in the maker community communicate with each other and it should be reflective of their needs and culture. The guideline I made for the design of DIY instructions aims to achieve this goal.

In the future, I plan to test this guideline by using it to make a DIY instruction and conduct a user study. The user study will ask novice makers to follow the instructions and build a DIY project. Adding humor or sarcasm to instructions is another area I plan to explore. I presume that studying popular DIY instructions on commonly used maker platforms will also give good insights into what factors interest makers. This literature review made me curious about the level of complexity that can be retained in the instruction set to facilitate learning but not intimidate novice makers and I would like to investigate that further.

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