Abstract
Multimedia prototypes of varying degrees of fidelity and interactivity could be a powerful tool for early stage startups to validate their business model assumptions especially product value proposition. This grounds on the prototype's ability to enhance user experience (UX) thereby making their feedback more accurate and reliable. This article reports practical experiences with consultancy projects involving European early stage startups focusing on the cocreation process of value proposition innovation amid pandemic. This includes the challenges faced in interacting with onsite customers, multimedia prototyping as a tool to foster remote customer involvement, and different challenges involved in prototype-driven cocreation like intellectual property rights, federal laws, motivation rewards, tool selection, and balancing customer expectations. The involvement of remote customers is fostered by the combination of varying degrees of fidelity and interactivity. Higher fidelity and interactivity prototypes are more applicable when a startup has a continuously increasing customer base, better market understanding, and customers having better product understanding. The practical experience indicates that resource-constrained startups could be greatly benefitted from the adoption of multimedia prototyping in their market research. The multimedia prototype development technologies could be easily adopted in startup business practices owing to zero purchase cost, ease of use, and usefulness. Their adoption is expected to become a norm for the "new normal" as the role of multimedia prototypes is trivial for lean startups enhancing the value of design thinking as well as customer development processes. However, there is an urgent need to define a systematic process for the selection of prototype development tools meeting the business needs and their seamless integration in startup business practices, thereby leveraging across the wider spectrum of prototyping tools market.

Startups are the providers of innovative prod-ucts in the market, but they have the highest failure rate as well. This had been reported by various agencies like Statista,[a] -Eurostate,[b] SBA,[c]

and CB Insights.[d] One of the biggest reasons for the high failure rates is their inability to launch products that solve the actual problems of the users (mismatch between product/market fit), attributable to requirement engineering (RE) related issues.[1,2]

Market knowledge acquisition is crucial for driving the commercialization of the product based on real facts rather than merely on assumptions or hypotheses. To achieve this, the startup team must formulate their interactions with potential customers as experimentations with the objective of each experiment being to test assumptions about the product value

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proposition. This experimentation is a continuous cocreation process conducted in a series of agile iterations using multimedia prototypes (or just prototypes hereafter) of varying degrees of fidelity and interactivity. Customers remain the important source of market knowledge in these experimentations.[3] Design thinking (continuous experimentation to further explore existing initial ideas or vision leading to commercialization) and customer development (continuous experimentation to identify initial ideas or vision, explore them further leading to commercialization) are the human-centric design approaches for problem solving i.e., the problem of acquiring market-related information to identify the product value proposition better. Continuous experimentations using multimedia prototyping with potential customers remain the core central activity in design thinking and customer development. These activities generate market knowledge through customer feedback because of their interaction with prototypes, which is more qualitative in the initial startup stages rather than quantitative.[4,5] The startups involving either of these approaches are also termed lean startups, i.e., they aim to avoid investing efforts in knowledge acquisition activities that do not create customer value.[6–8]

The customer interactions using prototypes were typically conducted face to face at a colocated physical space; an aspect that was heavily impacted by the haphazard arrival of pandemic and the resulting imposed social distancing norms and lockdowns. The role of online prototyping has become of paramount importance during pandemic but had been difficult to conduct because of limited support from research community and the hesitation of customers to participate remotely.[9]

The interaction with the multimedia prototypes helps the potential customers to enhance their understanding of the business idea, the proposed solution (abstract level), and features (detailed level) in an informative way using different multimedia elements like video, audio, text, animations, and graphics. Prototypes are helpful throughout the product life cycle and could involve a suitable design combination of varying degrees of fidelity (low to high) and interactivity (low to high). Fidelity refers to providing details and feeling of realism about the potential product or an idea. The interactivity refers to the ability of the prototype to provide navigational access to the customers, allowing them to interact with it. Increasing interactivity leads to increasing prototype fidelity. The increased interaction with prototypes as time progresses helps to enhance the user experience (UX) leading to more accurate and reliable feedback about the potential product.

This article is based on the perspectives shared by the 42 European startup teams quantitatively as well as qualitatively about the way they conducted prototyping with potential customers remotely during pandemic, setting a stage of the new normal. These startups are operating in the Telemedicine, drone logistics, sanitization, education, health & safety, Food, E-Commerce, Financial Technology, and shared mobility industries respectively. These startups were sampled from our professional network.

PROTOTYPING AND STARTUP ACTIVITIES

The early-stage startups involve experimentation for ideation, problem validation problem/solution fit, and product/market fit activities using prototypes of varying complexities.[11,12] Prototyping brings useful market knowledge that helps them to transform it into an actual but evolving product that at some time achieves fit with the market. Continuous product innovation to attract new customers and retaining existing ones is the tool for competitive advantage. Beyond this stage, the customer provides product feedback by interacting with real product version rather than the prototype using computationally advanced crowdsourcing infrastructures like social networking sites, App stores, etc. The techniques like Crowd-based RE,[10] A/B tests, etc. are employed to explicitly get customer feedback to drive further product evolutions. The explicit need for the prototype solution is thus minimized after product/market fit and hence this article scope is limited to startup activities until they reach product/market fit.

The objective of using prototyping is to acquire validated learning about product value proposition in the form of customer feedback. To adopt the prototype designing technology in a startup context, careful analysis should be done about monetary as well as nonmonetary costs and expected benefits as there is a gaunt line between success and burnouts (exhausting resources before meeting success). Technology adoption should consider the following criteria:

a) Usefulness (or usability):
   This signifies how useful the prototype is for the startup team, i.e., the ability of the prototype to validate assumptions.
b) Ease of use (startup):
   How easy is it for the startup team to develop the prototype? Do they need prior training for this?
c) Ease of use (customers):
   How easy is the prototype to be used by the customers? It should be possible for the customers to use it and understand the communicated information about the product.

d) Time to create prototype:
The time required to develop a prototype. The time should be less as spending too much time on its development will lead to market release delays.

e) Recyclability:
The ability of the prototype to be evolved as per evolving customer insights collected on a continuous basis.

f) Involved investment:
The cost involved in developing the prototype. This could include training costs, prototype creation tool costs, and missed person-hours that could otherwise be spent on startup activities.

The business needs, startup internal resources, and potential customer diversity in terms of their competencies and familiarity with the product determine the designing of the prototype solutions of varying fidelity and interactivity. For instance, a startup interacting with less technology-savvy users could find an animation prototype useful rather than a highly interactive prototype. Low fidelity prototypes provide less UX but could be meaningful for validating numerous business ideas quickly. The startup during their initial business operations has less market understanding and hence numerous product-related assumptions. It is better to maximize learning and minimize prototype development efforts using less interactive and low fidelity prototypes based on our experience with startups in professional proximity. The increasing prototyping development efforts should be based on working on validated facts brought by previous prototypes.

For instance, one Spanish startup with its sanitization technology product (product yet to be manufactured) decided to validate if U.S. cafe houses could be a meaningful customer segment using simple prototypes involving animations and videos. The customer segments were narrowed down with the increasing fidelity and interactivity of the prototypes leading to the selection of a global chain of hotel segments. These prototypes were reused at the time when it decided to globalize across the German market with little adaptation to local market conditions like changing the language to German from English. The prototyping experiences with both markets suggest some interesting points as mentioned below.

Problem Validation

Problem validation could be performed using basic multimedia digital prototypes. For instance, simple videos showing the sanitation process of the product along with meaningful text were used in the globalization operations of Spanish startup in the USA. The prototypes were powerful tools to highlight the lack of demand in cafe segments (as they were able to pivot towards take away services) but helped to identify the hotels, restaurants, and fashion retail segments as one of the promising segments. The overall effort made on creating the prototype was just a few hours.

Prototype Evolution

The evolution of the prototypes into higher fidelity and interactivity should be targeted on segments with validated product needs. For instance, the Spanish startup improved its video prototypes further by including information about how sanitization could bring business value and were shared on social media to drive user traffic to landing pages. The social media analytics helped to analyze the traffic behavior as the measure of medium-fidelity multimedia prototype impact.

Focused Customer Targeting

The further narrowed customer segments were targeted using higher fidelity prototype solutions, making it possible for them to gain better UX based on higher navigational access and greater fidelity. To achieve this, an interactive prototype application called Gamified Prototype for Better Business Decisions as shown in Figures 1 and 2, was designed by the startup team, which allows the customers to do the following:

a) Uploading photos of business premises:
Customers upload a series of pictures of their business premises, which were then transformed into three-dimensional (3-D) views. The customers then place the sanitation devices on any area of the 3-D picture. The sanitization impact was displayed by a series of waves showing its coverage (in square meters). Figure 1(b) shows that strong signals between pairs of sanitation devices exist which signifies that the area is well covered for sanitization.

b) Optimal purchase quantity Estimation:
This application estimates the size of the object represented in the picture, number of products placed by customers, and optimal number required to have 100% sanitization coverage of the object. This highly interactive activity allows them to use game playing to make business decisions about how many devices they would need to protect their business premises from coronavirus.

c) Feedback:
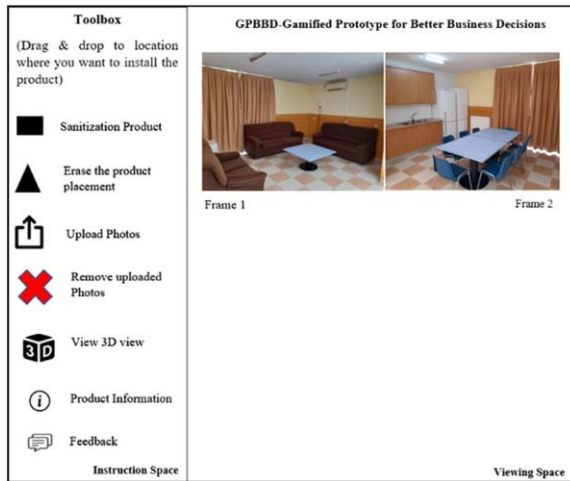The application also allows potential customers to provide their feedback, including the weaknesses.

FIGURE 1. GUI of Prototype solution. (To maintain startup anonymity, the photos of *"Crusa"* Residence of University of Alcala are taken as samples.)
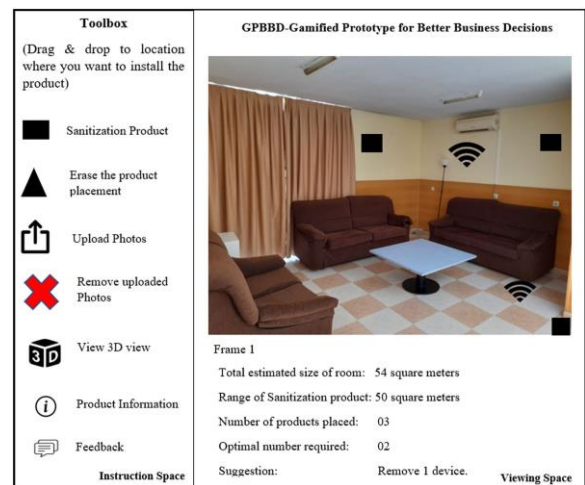

FIGURE 2. Placing product on room photograph. (To maintain startup anonymity, the photos of *"Crusa"* Residence of University of Alcala are taken as samples.)

For instance, one hotel customer after placing the product on the wall of the business reception specified that the surface sanitization condition of keeping the room empty while sanitization and time of around 45 minutes, will make it harder to be used in reception areas.

The reason for employing basic multimedia prototypes during initial startup business stages and more complex and interactive prototypes at later stages grounds on the following reasons:

a) Innovativeness:
The products of startups are usually very innovative. Their products usually have no pre-existing market (no similar offerings by competitors). This signifies that the customers may be unaware of the features offered by the product and even unaware of their own needs or expectations. This is through the interaction with such prototypes that they could better contribute to providing their expectations leading to the validation of value proposition hypotheses.

b) Brand Image:
Startups have no recognition as a brand in the market yet. The customers initially do not see any value in the startup product due to the lesser brand image associated with the startups. This is because most of the time customers attach product value to the brand image of the company offering that product. They initially hesitate to establish communication with the startups in customer

development or design thinking processes for RE (or value proposition innovation) processes.

To address the challenge of motivating customers to participate in the process of value proposition identification, the interests of the customers could be increased incrementally, starting with the basic prototypes, and transiting towards more complex and interactive ones.

The type of prototype as found employed by the startups for different activities considering their globalization approaches are given in Table 1.

PROTOTYPING BUSINESS OUTCOMES

Prototyping helped startups during the pandemic to achieve many business benefits like reduction of marketing efforts spent interacting with customer segments, quicker identification of promising global customer segments, ability to pivot rationally, gaining better brand image, and access to global market knowledge. For instance, a Spanish startup used prototypes to explore the German market for its sanitization product. The market research indicated that targeting the promising restaurant and fashion & clothing retail businesses could result in the sale of 86343 units with unit production cost reduced by 20% (because of economies of scale) and 10% selling price reduction (keeping profit margins the same). The rational estimation is driven by the startup ability to identify the customer segment and validate the urgency of their problem that will drive sales.

TABLE 1. Prototypes for different startup activities.

S. No.	Startup activities	Type of prototype suitable	Objective	Prototyping Solutions	Prototype creation tools used
1.	Ideation	Low Fidelity, less interactive	Quickly filter out bad ideas.	Basic animations, still images or videos showing holistic views of ideas.	Gimp, OpenShot, AdobeXD (used by less startups), Blender.
2.	Problem validation	Low Fidelity, less interactive	Validate effectiveness of problem.	Simple animations, still images or videos showing daily routine of customers, their pain points and their impact on the customer's lives.	Gimp, OpenShot, AdobeXD (used by less startups), Blender, Webflow.
3.	Problem/ solution fit	Low/medium Fidelity, less/ medium interactive	Validate if the proposed solution is the right approach to solve the problem.	UX/UI, animations and videos showing holistic solutions addressing the problem.	OpenShot, Inkscape, Audacity, AdobeXD (used by less startups), Framer
4.	Product/ market fit	Medium to High Fidelity, medium to highly interactive	Validate if the product has features that meet customer needs.	Detailed UX/UI designs, animated sequence of flow between UX/UI, Detailed animations, detailed videos.	AdobeXD (used by less startups), Webflow, Framer.

Further, one of the startups reported a 30% increase in their Facebook traffic and a 20% increase in product-related queries. Some startups also reported signing the selling agreement with the customers targeted with the prototypes, signaling the increasing sales. It will take time to measure prototyping business impact based on increased market share and analysis of financial statements strength over a prolonged time frame. However, in the two years of the pandemic, the prototyping has resulted in fostering good communication between startups and their potential markets leading to the increase in social media activities, product-related queries from potential customers, feedback from existing customers, sales, reducing time and money spent on undertaking misleading pivots as well as misleading markets. This has made startup market operations more rational, value-adding and optimal.

INVOLVED CHALLENGES

The prototyping involving remote customers has several challenges that need urgent attention:

a) Reverse Engineering:
Providing online access to the prototypes could invite reverse engineering by the competitors thereby requiring strong intellectual property protections.

b) Raising Expectations:
Prototypes could raise expectations of the customers and could be a sort of promise to deliver the functionality. The product release is impacted by the demands of mass customers rather than customized as per one customer's needs.

c) Government Regulations:
The foreign government regulation needs to be considered while requesting customer participation. For instance, as per German law, it is illegal to send emails to potential customers without their consent. In other words, startups must send them an e-mail to take their consent before actually sending them such marketing emails, due to strict email marketing rules in place. This is feasible to invite customers but the overhead with the consent and record management, will not be a good idea for resource-stripped startups, who are afraid of burnout rates and poor product/market fit.

d) Tool Selection:
There are numerous tools available for prototyping ranging from free and open source to highly professional premium versions. Startups need to experiment with them to make their adoption decision strategic.

e) Customer Motivation:
Decisions should be made about how to motivate customers to participate. Do extrinsic rewards need to be given? This will put a financial burden on cash-stripped startups.

EVALUATION OF PROTOTYPING TOOLS

The prototype development tools used by startups during pandemics include-Gimp, Inkscape, Audacity, Adobe XD, Webflow, and Framer. The reason for the selection of the tool is the familiarity with the tool based on previous working experience and popularity of the tool based on the recommendation by the person in proximity with the startup team. Thus, the selection of the tools was not made based on systematic evaluation of multiple criteria leading to the selection of appropriate technology. The following trend is observed across the startups.

1) The prototyping technologies offering services for a price are less used by startups. For instance, the startups who used Adobe XD are the ones who had competencies to use which impact their perception about usefulness and ease of use leading to stronger intention to use them.
2) The more interactive prototypes are developed using tools like framer and webflow as they are easier to use and incur less effort.
3) There is increased focus on free and open source (FOSS) tools by the startup community due to ease of use, minimal training requirements, and free to use features. However, they do not adopt FOSS technologies as per their needs, they simply use existing utilities.
4) The number of experimentations and subsequent prototype evolutions are higher during initial business operation. The use of basic multimedia prototypes like videos, animations, and graphics motivates them to adopt technologies like Gimp, Openshot, and Blender.
5) The impact of the prototypes are measured based on the sales arising out of the marketing efforts but such evaluation is rather less systematic and rigorous. Further, product sales are long-term impacts of good market research and not immediate measurements.
6) Web-based prototypes like those developed using Webflow are usually employed for validating the fit between product and the market. The reason is the availability of analytics support provided by online platforms like Wix, WordPress, etc. and the global reach of web-based tools across potential customers.

The following process activities should be undertaken by the startups in deciding about the prototyping for startup activities.

1) Identify internal competencies (like market familiarity, innovativeness of product, existing branding, existing customers of related product lines, etc.). The lower the competencies, the larger the reliance on the prototyping solutions, which motivates startups to move to the next step.
2) Identify the assumptions (or hypothesis) about the value proposition of the product and assumptions about the potential customer segments of the product.
3) Identify the multiple measurement criteria and period of analysis of criteria.
4) Identify the tools for the creation of the prototypes and type of multimedia elements to be used (basic during initial startup activities and after that more complex). The selection is based on the criteria given in Table 2.
5) Design the prototypes and update them based on the accurate analytics of measurement criteria as the interactions progress with the customers.

The startup teams were asked for an evaluation of eight prototype development technologies against the parameters mentioned in section "Prototyping & Startup Activities." The results are given in Table 2. The evaluation scale of 1–5 was used; 1 refers to unfavorable value while 5 refers to favorable value to the startup. The graphical representation of the results (see Table 2) is given in Figure 3.

The results provide some meaningful insights as discussed below.

1) All tools were found useful by the startup team owing to their ability to create prototypes with the ability to gather rich customer feedback. Prototypes help to gather feedback even if they may not be meticulous, raise customer product awareness and raise their interest making their future participation in design thinking or customer development processes easier.
2) On average, the startup team found all the tools easy to use owing to the availability of the tutorials and free video materials across channels like Youtube. The tools like Gimp, Inkscape, Audacity, and Adobe XD are rated on average as they require the startup team to get some practice before actually starting using these tools. Rest tools being targeted towards typically "non-coders" (or people with not much prior experience), is much easier to use. Further, these tools are faster to work with compared with Gimp, Inkscape, Audacity

TABLE 2. Comparative analysis.

Tool	Evaluation Parameters						
	Usefulness	Ease of use (startup)	Ease of use (customers)	Time to create prototype[*]	Recyclability	Involved investment[*]	Overall Assessment
Gimp	5	3	5	3,5	3	3	3
Inkscape	5	3	5	3,5	3	3	3
Audacity	5	3	5	3,5	3	3	3
Adobe XD	5	3	5	4	4	4	4
OpenShot	5	5	5	5	5	5	5
Blender	5	5	5	5	5	5	5
Webflow	5	5	5	5	5	5	5
Framer	5	5	5	5	5	5	5

[*]Value of 5 signifies a favorable value to startup (depending on the aspect). For instance, the aspects favorable for the startups include-high value of aspects like usefulness, Ease of use, Recyclability, and lower value of aspects like time to create a prototype and involved investment. Higher Usefulness and lower involved investment aspects signify favorable aspects for the startups and must be evaluated to the rating of 5.

and Adobe XD (which require prior hands-on experience with them, more the previous experience lower is the future prototype development time).

3) The developed prototypes were easier to use by the customers. The reason is that the prototype solutions created provided much easier communication of product-related information at no additional effort from customers.

4) The prototypes were created using Gimp, Inkscape, Audacity, and Adobe XD are recyclable on average. The reason is that the ability to evolve the prototype depends on the creativity and experience of the multimedia designer. On the contrary, rest tools provide the start-up team a simple platform to edit existing multimedia elements (for instance, video frames).

5) Gimp, Inkscape, Audacity, and Adobe XD require some prior training to enhance the startup team's ability to create prototypes, which increases the investment required from the startup side. The rest tools being targeted towards "non-coders" are easier to use and hence need tiny investment from the startup side.

Even though the individual tools were evaluated differently on different evaluation criteria, they highlight the increased importance of prototypes for lean startups to explore the product market. The tools that need no prior experience working with them, provide
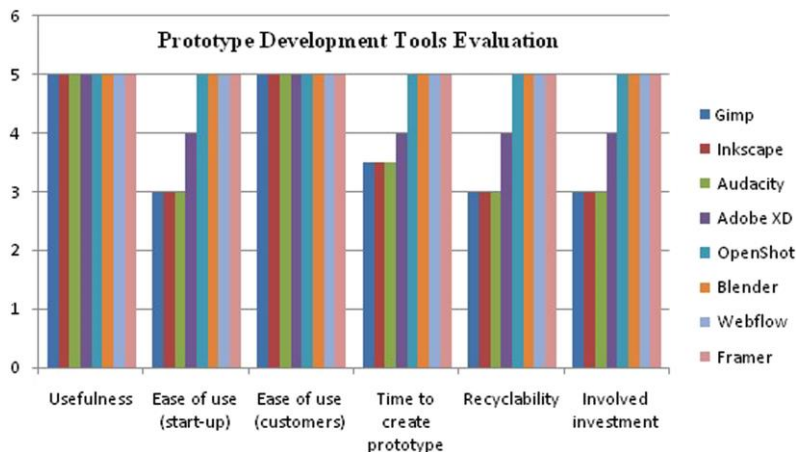

FIGURE 3. Comparative analysis of prototype development tools.

an opportunity for startups to use them in their settings, adopt them as per their requirements (if they are open source), and switch to other tools (if existing tools do not meet their needs). The FOSS tools have greater applicability in the startup context, providing them a cost effective and timely response to market knowledge acquisition.

DISCUSSION AND INSIGHTS

Prototyping is an effective way for a startup team to learn about the market and deliver a successful product driven by learned market facts. Prototyping should be a dynamic, continuous, and systematic process where diverse users are exposed to prototypes of varying degrees of fidelity and interactivity. The prototype evolution in terms of fidelity and interactivity should be driven by validated learning brought by previous prototypes. Further, there is a need to systematically adopt prototype development technologies that help startups to meet their business needs, are seamlessly integrated with their business operations and support prototype evolution. It is better to initiate with less fidelity and less interactive prototypes and gradually evolving them in higher fidelity and interactivity with increasing market understanding and more focused targeting of the customer segments. This helps startups to perform validations with minimal efforts and avoid wasting efforts on activities less valuable because of pivots. This also helps customers to understand the product solution gradually and capture interest to contribute to their innovation. This is because the customers pass through a journey of increased understanding about the product in terms of problems they solve, how the solution will make their life easier, and what additional benefits they will get from it.

The increase in interactivity and fidelity of the prototype helps the customer to make this journey. For instance, one of the startups in our professional proximity exposed a web pages prototype to the vulnerable group (potential customer segment) but most of them showed resistance to cooperate further. This is because the prototype failed to explain the benefits of the product in the easiest terms (the vulnerable group was less technology savvy) and users always have resistance to make the first move to adopt a new solution in their routine life (except those who are early adopters of technology which is unlikely in the group). Higher fidelity and more interactive prototypes are recommended only when target customers are not only clearly visible but their interest in the product has raised to a good level, business continuity is certain and customer feedback at a finer level of gratuity is required.

Once the challenge of selection of prototype development technology and evolution of prototypes is addressed, the next issue is which channel to use for reaching the remote customers. Social networking technologies are one of the powerful ways to reach masses remotely. Search engine marketing (SEM) is one of the powerful tools to involve customers in prototyping sessions and take advantage of strong analytical support available. The continued use of prototypes in continuous experimentation enhances the experience of the startup team with the technology thereby making its adoption easier within their business context. The social networking technology also makes it possible to leverage across the social networks of the targeted customer segments thereby benefiting from the strong word of mouth marketing. Gamification-based prototypes could be a powerful tool to continue customer support in value proposition innovation. One of the startups in our professional proximity created five video prototypes in German language as Facebook advertisements to give customers a feeling of freshness in the content. How exposure of the same customer segments with repetitive prototyping multimedia elements could be avoided is another issue.

The pandemic created a different situation for the startup community, forcing them to step out of the "face to face" interaction for prototyping and try adopting the power of social media, SEM and prototyping with remote users. The startup community responded well to the challenges posted by the pandemic by making a blended use of the available technological services. Now as we are going back to "normal," with the business community recovering through the pandemic impacts, it is a great opportunity to learn from the best practices from the individual cases, rather than seeking the generalizability across the practices, to pave a way for a golden road map for the startup community. We see few implications for the following actors of business innovation—

a) Startup community: It is advisable to make their prototyping practices and experiences with the different tools to the startup community public. Adaption as well as adoption of prototype development technologies (especially FOSS) in business practices should be carried out strategically. There is a potential even in prototypes of lower fidelity and lower interactivity. So, startups should try adopting such prototypes rather than merely focusing on higher fidelity and interactivity ones. The focus while

selecting prototype design should be to elicit maximum learning by making the customer journey with the product easier. There is also a need to accurately select the prototype development tool that best meets their business needs with minimal effort. There is a need to leverage the benefits scattered across the wide spectrum of such tools marking an urgent need for the availability of more empirical studies about tool evaluation, helping the startups to at least make initial decisions about the technology selection.

b) Customers:
Prototyping is a way to bridge knowledge gaps between startup and customers and make them synchronized. Their participation is crucial, and their early participation could help in wasting economic resources on less promising business ideas.

Diverse prototypes across different startup activities and suitable social media as communication platforms, provide greater access to the potential market. The pandemic taughta good lesson—there are numerous tools available to develop prototypes, online presence of customers across social media is an opportunity and different complex prototypes have real applicability across different startup activities.

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