ROCKIN' AROUND THE PROTOTYPE: AN EDUCATIONAL EXPERIMENT OF COLLABORATING WITH A USER INNOVATION COLLECTIVE

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ABSTRACT
The paper discusses the importance of real-life context in design education and presents a case study on the coordination of stakeholders' interests around a prototype through the lens of design research and teaching. Collaboration with user innovators exposed design students to real-world challenges and constraints that they would not have encountered in the classroom. The study highlights how experiential knowledge is generated through collaboration between academics, practitioners, and specialists from various domains. The paper describes the study context, the primary human and technological actors, and the knowledge domains involved. It concludes by discussing the results and addressing strategies for future research and implementation, including educating individuals to recognise and respect professional boundaries.

Keywords: User collective, prototype, codesign, electric snowmobile, Arctic design, design education

1 INTRODUCTION
Essentially, design education as a relational and context-dependent practice [1] constantly requires up-to-date direct links to the 'outer world' to encourage diverse societal interaction, deeper understanding and solving problems for real-life contexts [2]. In the industrial design and engineering domain, it is of particular importance to teach would-be professionals by utilising a collaborative approach where all the stakeholders are present – including various experts who inform the process at the different stages – and engaged in real-life research and development activities throughout the entire project [3]. However, in an industry context, it is a rare instance when students are admitted to taking part in real projects. Also, in such a context, successful design – from problem definition to final design implementation – is a time and resource constrained activity, which hardly could fit in a typical educational cycle. To approach the complex issues at hand, we present a case study involving a handcrafted metal framework prototype of an electric vehicle for extreme terrains. This prototype enabled a multi-actor collaboration between enthusiastic developers and users, academics (experts in design and control science), and industrial design students and teachers. The prototype served as a hub for diverse activities among various stakeholders and product contributors, leading to the development of innovative ideas and refinement of individual paths. Through this collaboration, participants were able to gain new insights into the challenges faced by each other, resulting in a more comprehensive approach to addressing the issues at hand. By working together, stakeholders were able to identify new opportunities for innovation and develop solutions that would not have been possible through individual efforts alone.
The paper is structured as follows: The second section outlines the employed data and methods. The next section describes the study context, the primary human and technological actors, and the knowledge domains involved. The case study is presented in Section 4, which focuses on the coordination of stakeholders' interests evolving around the prototype and relevant outcomes through the lens of design education. The conclusion of the paper contains discussion of the results and addresses strategies for future research and implementation.

2 METHODS AND DATA

The study began as experiential making when the first working prototype of a light electric snowmobile was made in 2019. Since then, a place-based approach has been employed to advance the prototype through a series of field tests and changes made on-site. The research timescale of 2019–2022 also encompasses the valley of death, i.e., the institutional, financial, and skill gaps in the transition from an existing or emerging technology to the creation of a compelling new market-driven business [4]. Usually, because of this gap between development of science and development of commercial products, many opportunities to create technology ventures remain undeveloped and unexploited, and some products never even get to the point where a designer can work on them. In our case, however, the design and styling phase was able to happen during the valley of death period because of the connections between stakeholders that this paper describes.

The study uses ethnographic immersion and qualitative data collection based on semi-structured interviews in various localities – from manufacturing workshops to potential settings of use – with developers, potential users, and testers (n = 18), as well as participant observations (riding prototypes and working closely with makers at the manufacturing facilities).

At the stage of designerly work, using the place-based approach of the Arctic Design School [5], the qualitative data collected was used to make a series of design proposals for how future overland electric vehicles for remote northern areas might look. "Design classics" [6] such as designing by metaphor, low-fidelity prototyping, user profiling, and intensive sketching were employed during the design phase.

3 THE CONTEXT AND THE PRIMARY ACTORS

In the background, there were three independent storylines that eventually intertwined. (1) of the team of university-based design researchers from the extreme environment design lab who won a large 5-year grant (Russian Science Foundation No. 17-78-20047, 2017-2022) for exploring, grounding, and teaching Arctic design as a new field of design theory and practice for remote and sparsely populated regions with extreme environmental conditions [7]; (2) of control scientists from the lab of active systems specialising in formal modeling and complex evaluation mechanisms; and (3) of a startup of enthusiast tinkerers. In this paper, we illuminate just a part of these collaborative encounters between science, technology, and education related to interactions with a physical prototype of an electric snow vehicle named *S-bike*, with a focus on its educational relevance.

3.1 The Company

The case company, i.e., E-Max Laboratory of Electric Transport (hereinafter E-Max), is initially a user collective specialised on customisation and electric conversion of standard vehicles, predominantly motorbikes and formally established as a small enterprise in 2013. The breakthrough occurred in 2014, when E-max team conducted a successful conversion of a gasoline Yamaha 450 into electric version, which later, in 2017, passed several stages of the international Africa Eco Race 2017. It was the first electric motorbike appeared at the international class rally. Over the next four years, there were other successful conversions from gasoline to electric conducted, including several dirt bikes and street motorcycles, as well as cars and ATVs. Since 2020, the company has been manufacturing its in-house development DWX 250 awarded the best electric enduro in Russia in 2021. Today, the company employs about 10-15 people (depending on the ongoing volume of orders).

3.2 The Prototype

The main technological actor, so-called S-bike, is a working prototype of a lightweight mini-snowmobile with a front ski and a narrow track with an electric wheel-motor unit inside that reaches a maximum speed of 70 km/h. It contains a compact battery (there is a space for two units) with one-charge cruising range of 50 kilometres.

S-bike is the result of the efforts of a small group of enthusiasts to implement the concept of developing a relatively light and compact electric-powered vehicle for driving upon snow. The idea of such a vehicle emerged among two friends and passionate snow riders while experimenting on lightweight structures in their garage in 2017-2018. One of them was a gifted engineer and tinkerer and another one was a technical scientist and a senior researcher at the Institute of Control Sciences, who also engaged successful structures as subjects of automation tests in his lab. They initially attempted to equip a fat bike (an off-road bicycle with oversized tires) with an electric motor, and it was able to operate. However, it was only useful on the rolled path. It was futile to attempt to ride it in the deep snow. It implies that it is necessary to forego wheels, if not make them as massive as for off-road vehicles. In the meantime, there has been a tried-and-true way to move on low-bearing surfaces, like snow, for a long time: it is the track. On a standard motorcycle, a specialised track set can be installed to create a highly functional vehicle.

In early 2019, the inventors approached E-Max company with the idea of electrification of their snow machine. The technological challenge was accepted, and soon E-Max supplied a kit for electric conversion that included a traction electric motor, a battery, and a controller with controls. In summer 2019, the first workable prototype was developed and tested in Mount Elbrus, the highest peak of the Caucasus Mountains. However, the battery collapsed (exploded) shortly after the ride has started, but that accident, in fact, inspired the team to continue experiments. Since a workable prototype has been made in the end of 2019 (Figure 1), the multi-actor collaboration has begun and centred around it. First, the inventors of the first version of the S-bike joined the E-Max team and set up a joint manufacturing facility. Mathematicians also joined the design researchers to work on a state-funded multidisciplinary research project [8], and the design researchers, who are also teachers, created a Master's-level course and launched a students' contest about electric-powered Arctic mobility.

Figure 1. The S-bike prototype. Image credits: Nikolai Korgin

4 CASE STUDY

Working with and around the prototype was accomplished in multiple directions simultaneously. Below, we consider each direction within its primary group.

4.1 Researchers

A state-funded project by the academic community of design researchers and control scientists (mathematicians) laid the methodological and financial groundwork. This project made it possible for expeditions and test trials, field research on potential audiences and users, and the discovery of new, unexpected audiences, like reindeer herders, mountain rescuers, and even special forces.

4.1.1 Outcomes

During the two years of the project (2020-2022), the research team went on three field trips: one to the North Caucasus and two to the Kola Peninsula. On these trips, the S-bike was tested in potential target (climatic and infrastructure) conditions of use, and surveys were done using structured and semi-structured interviews and participant observation to find out what tourists, researchers, and representatives of the indigenous community need with regard to individual mobility. The expeditions' overall results are as follows: A qualitative assessment of the design and engineering proposals was conducted with the participation of the ATV manufacturers and potential users in the test localities of the North Caucasus and Khibiny Mountains (alpine skiing complexes) and the tundra (reindeer-herding bases), which revealed, on the one hand, fundamental mistakes made during the design and assembly, i.e. redundancies of development as judged by individual criteria, and, on the other hand, confirmed both the adaptability of the chosen format of manufacturing, i.e., a small innovative enterprise, and of the product, i.e., a small-sized vehicle, that gives a user a degree of control in extreme situations of failure.

Through the research project, funds were also made available (indirectly) for concept development by the lead designer, who was a member of the design research team, and for "homebrew prototyping" in the studio, and for student internships at manufacturing facilities.

4.2 Users-makers

When the prototype was created, the design and styling phase began. The manufacturing company needed to design a marketable product so that the first batch could be produced and successfully sold. At that point, it transitioned from a user collective to "developer immersion in use," one of the most effective strategies for finding inspiration when creating something new [9]. This strategy places a premium on the designer's experience in the user's domain, or the context in which the product or service is utilised. In the case of the S-bike, the initial inventors became true designers due to their extensive product knowledge and passion, so the commissioned industrial designer (a member of the research team) served as their "drawing hand." (Figure 2).

Figure 2. The S-bike concept design. Left: 3D model next to the styling analog DWX 250 electric motorbike by E-Max. Middle: prototyping in the workshop. Right: testing in the field. Image credits: Nikita Klyusov, Nikolai Korgin

4.2.1 Outcomes

For the industry, the outcome is an adaptable model of the process for manufacturing marketable products for harsh environments, as demonstrated by a series of functional yet designer-touched ready-mades. The transition from "desktop design" to the real world is especially important in terms of understanding what happens in the real world. The "user as designer" strategy turned out to be hard to implement for both designers and users. On the one hand, it forced designers to put aside their creative egos and become smart tools in the hands of smart users. On the other hand, it caused users to undervalue the designer's contribution. In our case, the "designer-company" collaboration ended when both parties recognised their respective limitations. At the subsequent stage, the transformation of the prototype into a commercial product required more specific expertise: that of industrial engineers to complete the mould and that of graphic and media designers to create a memorable visual identity. As a result, the S-bike has recently been released under the name Snegir (a bullfinch bird in Russian) and is now freely available as of December 2022.

4.3 Students

Student engagement and participation constituted a distinct aspect that was neither immediately commercialisable nor merely speculative. Focusing on "their own circle," i.e., the community of motorcyclists, the makers' collective initially insisted on creating a product that resembled a motorcycle but was equipped with skis and a track; this was the primary vector for the development of the product's main design (Figure 2, left).

The driving experience of an electric snowmobile is unlike that of a motorcycle or an internal combustion engine (ICE)-powered snowmobile, and a driver's license is not required. So, the students started by coming up with ideas about how this unique experience, the potential of electric drive, and the needs and opportunities of the harsh operating environment could be joined together to shape an innovative transport vehicle.

The student experience of working with the prototype began with a 3D scanned model of the original physical structure (Figure 3, left). As students were 2,000 kilometres away from the workshop, the makers scanned and sent the original model for further digitalisation and refinement. This 3D model, however, neither conveyed the proportions and ergonomics nor the experience of riding such a vehicle. Thus, the students made a full-scale, low-fidelity prototype out of foam board (Figure 3, right).

Figure 3. Prototyping the prototype. Left: results of 3D scanning and modeling. Right: low fidelity tangible prototype. Image credits: Nikolai Korgin, Svetlana Usenyuk-Kravchuk

As part of the design concept development process, students proposed several ideas that diverged significantly from the original design. These included utilising the distinctive plasticity of sheet material, exploring symbolic imagery through silhouette, and combining the expressive and constructive potential of generative design (Figure 4).

Figure 4. Selection of students' proposals. Image credits: Ignat Evstafiev, Ekaterina Fomina

In between studio work, there were several short-term visits to the workshop facilities, as well as additional low fidelity prototyping on-site. At this point, would-be designers not only tested their ideas and concepts to get helpful, and sometimes sobering, feedback from real users and makers, but they also considered the exact manufacturing process and learned about its limits and possibilities. In the case of small-scale production by a user collective, there are certain nuances: for instance, not every component can be produced locally, and many components must be sourced from larger manufacturers.

4.3.1 Outcomes

Even though the makers' collective lacked prior experience working with design students and was unfamiliar with the specific goals and tasks of a traditional studio-based design education process, they were eventually inspired to engage with students and viewed it as an investment in their own future. Yet, the process of coordinating interests was rather difficult and required rebalancing between real-world needs, short-term marketing aims, and a long-term vision for all-season electric mobility and commercialising user innovations. All of the original stakeholders – both academics and users-makers – put the company's new priorities and goals into action through the design student competition they set up (Figure 5). In contrast to many other student design competitions, the prizes for this one focused on the product, the company, and, in a broader sense, developing place-based design solutions in line with the Arctic design approach. The prizes were a trip to the testing area on the Kola Peninsula and a funded one-month internship at E-Max.

Figure 5. Selected projects. Image credits: Kirill Mukaseev, Daria Samofeeva, Lee Lin'vei

5 CONCLUSIONS

This case revolves around a prototype creating multiple entanglements between user innovation communities [10], situated learning [11], and participatory and co-design [12]. Expanding on the latter, our main insight into coordination of interests is that collaborative design process – considered primarily horizontal and democratising – at a certain stage can (and should) become intrinsically non-democratic and hierarchical. When two (or more) stakeholders are teaming up based on their creative sovereignty, at some point, to sustain the development process they have to become consciously unequal: one agrees to sacrifice their interests (e.g., professional, financial), i.e., agrees to be ridden, and the other is ready to ride. This inequality, we argue, is of key importance for the project implementation and further capacitation of stakeholders, especially when their paths will diverge after all. In our case, there are multiple actors, each of whom is the creator of a work of personal significance — either turning a prototype into a product, doing research through the prototype, or learning design from the real-life context. We described stakeholders as being unequally placed in front of the prototype, and this inequality is exactly what makes them rock', i.e., moving along their own paths while taking into account individual limitations.

The above discussion has direct implications for design education. Collaboration with user innovators in the case study exposed design students to real-world challenges and constraints that they would not have encountered in the classroom. Also, as Markauskaite and Wrigley note, for design education to remain productive, it must embrace the growing disciplinary diversity and richness to truly push the knowledge boundaries [1, p. 140]. This necessitates not only increasing the number of participants with diverse knowledge and expertise involved in co-design projects but also educating and training individuals to recognise and respect the limits of their own professional field.

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