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EXPLORE, RESPOND, ADAPT: THE ROLE OF RISK AND EXPERTISE IN HYBRID (SOFT/HARD) PRODUCT EDUCATION

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ABSTRACT
Design education is working in an expanding field of environmental contexts. The coming generations will witness changing climates that drive them toward migration to the poles and survivalism. As we explore and settle further from our familiar locales, how might we respond to risk before we adapt? Why are risk and expertise in extreme environments relevant to future design education?

In accessing extreme environments, humans require technical products and protective equipment (PPE) to survive and thrive. This paper shares experience from hybrid (soft and hard) product design education where extremes (environment and context) inform the curriculum. Projects are challenge-based and set in high-risk environments. Starting from the unfamiliar environmental contexts, students learn from experts who have mitigated risks and developed specialty knowledge-base and technical skills relevant to this expanded field. The year 3 curriculum model is collaborative, explorative and technically demanding with a 7-week project involving expertise in technology, the body and context/users. Iterative prototyping happens in on-site speciality labs with early and frequent testing. The student teams self-organize and project-manage their way to a full scale, functional prototype that is evaluated through design scenarios, expert feedback, field-based test protocols (on and off-site).

This paper reflects on project outcomes over 5 years. Informed by student and stakeholder feedback, it offers perspectives and recommendations on the necessity of an expanded 'environmental' field for this generation of risk-engaged designers. Future-proofing design education derives benefit from introducing the unfamiliar and unknowns so students can explore, respond, and adapt as designers.

Keywords: Protective equipment, extreme environments, human factors, technologies, industry partnerships, climate crisis

1 INTRODUCTION
Over the coming decades, design education will necessitate an awareness of an 'expanded field' of environmental contexts due in part to climate change and there is a growing human desire to democratise exploration and adventure tourism to all corners and surfaces of the planet [1]. These shifts require additional demands in the products that enable humans to explore, respond and adapt. The impact of climate change will be exposure to rapid weather systems, with more extremes (temperature, humidity, precipitation), and much of it involving coastal settings. Scientist/Author Jim Al-Khalili writes; *"Predictions about the way in which our lives will change thanks to advances in science and technology are spread across that wide expanse between the inevitable and the utterly foreseen*" [2] Climate Change Scientist Julia Slingo adds that the interaction of the systems on which we rely, both in everyday situations and in emergencies (e.g. telecommunications, transportation, etc.), are the basis for "*a new set of circumstances and pose new challenges about how secure we will be in the future"* and these aspects of the changing environmental context necessitate the need to *"go beyond plan and prepare to adapt - to climate-proof our lives"* [3]. Understanding the challenges requires us to access regions of the planet that test the limits of technology and the human body. While there are many places on the planet that are conducive to human life, there are many places where humans go that require them to prepare and adapt to extreme conditions. Our interest to date has been in polar regions, oceans, and mountains. In pursuit of these settings, we push the limits of the human body and protective equipment. In doing so, we encounter challenges that come with living in a range of non-ideal environments. It is these non-ideal, extraordinary, extreme environments that raise our interest and expand the learning of

our students to work beyond what is known and ideal. We seek learning opportunities based in the survival measures offered by protective apparel/equipment/devices that human's pair with to explore extreme environments, or *survival through design*.

2 ENVIRONMENTAL CONTEXTS AS [DESIGN] EDUCATION PRACTICE

While the 'field' varies in location and context, the exploration of more extreme environments is growing in popularity and therein presents an opportunity to respond to user needs and meet the environmental demands. What is *every day* to some who regularly plan, prepare, and access environment-based recreation, may soon become extreme as conditions shift unexpectedly.

The peri-urban zone is a central part of the structure and functioning of urban systems, as it represents an important extension of major cities, accessed for resources, for recreation and leisure, and for infrastructure developments [4]. Regions offering mountain, forest and coastal features draw increasing numbers to the peri-urban environment, and the four-season access translates into incidents requiring Search and Rescue (SAR) interventions across numerous settings and weather conditions. Annual regional incident reports indicate a general increase in responses over the last 30 years (Figure 1b), more than population increases, supporting the trend towards a growing adventure tourism and the accompanying risks [5].

Figure 1a. Search and Rescue situation in alpine, winter conditions,

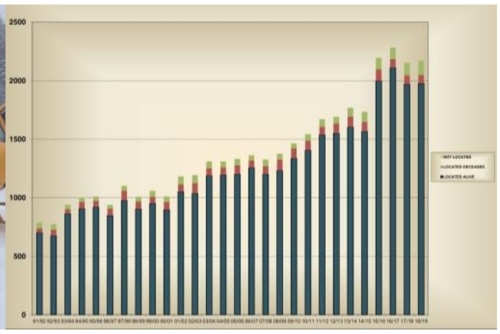

Figure 1b. Search and Rescue (SARS) Results 1991/92 to 2018/19 (B.C. SARS)

Adventure tourism and eco-education in polar climates is also increasing. Maher [6] attributes the increases to the unknown nature of arctic locales, the attention of the media to climate change, and to notable designations such as International Polar Year (IPY). He sums up the underlying reasons for the trend in the sobering statement that people want to "*see it before it's gone*". This desire to understand and connect with our planet and enjoy all that nature has to offer results in more people venturing into this cold and often harsh climate. Furthermore, new technologies in materials and equipment enable people to enjoy outdoor pursuits regardless of the weather in peri-urban areas, and to push the limits and explore the cold climates in more remote arctic settings in higher numbers, which in turn leads to greater risks. Institutional expertise, peri-urban and proximal-polar geographical setting, and industrial/academic partners are considered alongside the growing environmental need for students to respond to the challenges afforded by this approach to design education.

3 EXPANSIVE ENVIRONMENTAL [DESIGN] METHODOLOGY

In the field of design education, this meeting of object and opportunity is informing the curriculum in the design of technical apparel and equipment, but it offers potential across design. Meyer and Norman [7] note that "*skills for developing creative solutions to complex problems are increasingly essential.*" They group design challenges into performance, systemic, contextual and global and highlight the skills most relevant to each group before offering that *"designer's responsibilities are expanding beyond the technical to include the organizational and managerial."* Their position is to expand beyond a design school's emphasis on practice, and on the research university's emphasis on evidence, theory, and principles. What does it mean for a programme to offer both evidence-based design theory and principles alongside technical, practice-based education?

Designers are moving their attention from making-to-making sense of complex information to define the problem. Working with others, across disciplines, is inherent in these problems and this introduces multi-modal methodology. In the context of adventure tourism, these methodologies could include the knowledge of the limitations of the human body in various environments, technical tests for protective equipment, human and equipment-related demands for exposure, and competences to recover from unexpected incidents where human or equipment are insufficient for comfort or safety. In this case, curriculum draws on technical information from psychology, physiology, material science, geography, etc. and professionals in first response, health and safety, medicine, materials, and engineering, etc. The curriculum is collaborative, explorative and involves technically challenging prototyping to various degrees of fidelity. This 'expanded field' benefits from technologies and partnerships with emerging industries and the role of design is in understanding the layering and intersections of applied expertise that can be achieved with design methodologies that facilitate curriculum innovation.

4 THE ROLE OF THE [DESIGN] PROJECT

This paper exemplifies a project-based approach to accessing an expanded field of environmental contexts. Students confer with users to gather and analyse their needs, with the aim of innovatively and economically improving function, performance, and comfort, before considering manufacturing requirements in the development of solutions. At its core, the project involves experts as providers of knowledge, experience-based examples to contextualize that knowledge, and as mentors: **body expert, product expert,** and **user expert.** The project sits in term 6 (8 terms, 4 years) of an undergraduate design degree, when students are also undergoing industry experience practicums and considering careers choices. At the outset, the project serves as a 'testbed' as it requires them to identify their role, noting their strengths, skills, and area of specialization, in addition possible 'non-design' positions of leadership, project management, and team negotiation. Martela [8] identifies some of the essential benefits of teamwork in its' ability to focus on practical and emotional characteristics. The project and teams are given the space and the autonomy to self-organize and proceed with faculty guidance. In doing so, the intent is for them to achieve the characteristics of what Martela [8] describes as a '*well-functioning team'*, such as '*asking and giving advice, helping each other out, sharing the workload fairly, knowing each other's strengths and weaknesses, and trusting each other*.'

Project evaluation was informed by a survey distributed to all course alumni (2017-2021), who were reminded of the course contexts: dangerous and unpredictable. The questions informed insights into aspects of the course's learning objectives, content and activities in the areas of learning impact, risk, and expertise. Question formats included 5-point Likert scale, checklists and short answer.

5 A PROJECT OF ENVIRONMENTAL [DESIGN] CONTEXTS: A CASE STUDY

The project arose from discussions with industry: the timing reflects the industry standard for innovation projects (6-7 weeks) and the output reflects the manufacturing specialty of the region. The project runs in cycles, so yearly cohorts join a project 'in progress', which facilitates critical analysis of prior approaches but requires students to apply core principles to a new context; thus, integrating different experts, users, and criteria. The expansive and collaborative project space is presented across 5 iterations (2017-2021). The original project on which the course was based, was brought to the institution by a well-established industry partner in the protective apparel and equipment sector. Table 1 provides an overview of the projects to date, each for specific user and environmental context.

The project cycle is set up to ladder, with each set of 3 iterations building on aspects of the prior prototype. For example, year 1 thermal rewarming project was deployed and tested in field conditions using simulated protocols by students in the Design of Technical Apparel programme and professional SAR personnel. Year 2 thermal rewarming project underwent field-based testing aboard a vessel during a snorkel safari expedition where the prototype was deployed with a dry user and all features were demonstrated during simulated protocols. Year 3 thermal rewarming project iteration was deployed on a rescue vessel using a test protocol written for a coast guard team. The data from the testing was provided to the next group of students to build upon. The following figures show some of the key activities integrated into the project, defining the environmental context-specific functional hierarchy (Figure 2), design development (Figure 3), deployment examples (Figure 4).

Table 1. Products for extreme contexts soft & hard goods projects

Focus	Project	Context/ Environment	Experts	Methodologies	Concept Prototype
Focus: Thermal Rewarming	**2017: PERI-URBAN BURRITO** TEAM SIZE: 5	Peri-urban (mountains, forested, snow, freshwater and coastal)	**USER:** Alpine Search Rescue Leader, Ski Patrol **BODY:** Thermal Physiologist **PRODUCT:** Engineer, Research and Development Manager	**SITE VISIT:** North Shore Rescue Community Base and Mustang Survival	Hooded hypothermia bag with three-way zipper for accessing points for vital areas and roll up and gusset for adjustability. 
	2018: POLAR BURRITO TEAM SIZE: 6 (1 International Exchange student)	Remote, Polar, water, shore, and ice pack	**USER:** Sedna Epic Expedition Leader, Polar Snorkeler **BODY:** Environmental Physiologist **PRODUCT:** Engineer, Research and Development Manager	**SITE VISIT:** Horseshoe Bay Marina / Sea Dragon Charters , and Mustang Survival FIELD TESTING: Snorkel Safari	Fur-hooded multi-layered extreme hypothermia bag with inflatable pillow, three-way zipper for accessing vital areas, and specialised locator toggle. 
	2019: MARINE BURRITO TEAM SIZE: 6 (2 international Exchange students)	Marine, commercial, recreational watercraft users.	**USER:** Dive Leader, Crew, Canadian Coast Guard **BODY:** Environmental physiologist **PRODUCT:** Engineer, Research and Development Manager	**SITE VISIT:** Coast Guard (Sea Island), Mustang Survival, Simon Fraser University Climate Laboratory for Exercise and Environmental Physiology (LEEP)	Hooded hypothermia bag with self-inflating pad, contour zipper for accessing vital areas 
Focus: Pneumatic building	**2020: HIGH ALTITUDE (HYPERBARIC)** TEAM SIZE: 10	High altitude, mountaineering, emergency descent.	**USER:** 2 Amateur Mountaineers (7 summit) **BODY:** Hyperbaric Physiologists, Wilderness and Expedition Medicine **PRODUCT:** Engineer, Research and Development Manager & Aerospace Design Engineer	**SITE VISIT:** Thin Red Line Aerospace, Richmond Dyke (rock formation).	Lightweight portable, roll-top hyperbaric chamber and pump system, with windows for communication /monitoring victims of high altitude illness 
	2021: ANALOG ASTRONAUT HABITAT (HYPERBARIC) TEAM SIZE: 10	Lava Tube, remote, temperate climate	**USER:** Anaglogous Astronauts **BODY:** **PRODUCT:** Engineer, Research and Development Manager	No site visits due to pandemic	Habitat for Analgous space mission in Iceland. Integrated simulated airlock, thermal floor and layered materials for thermoregulation 

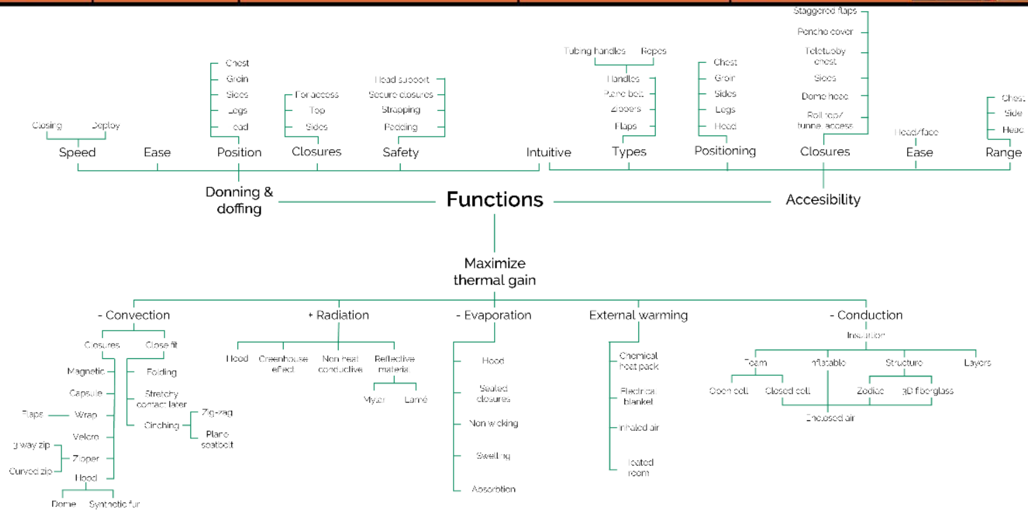

Figure 2. Functional planning and prototype assessment matrix (ENIX)

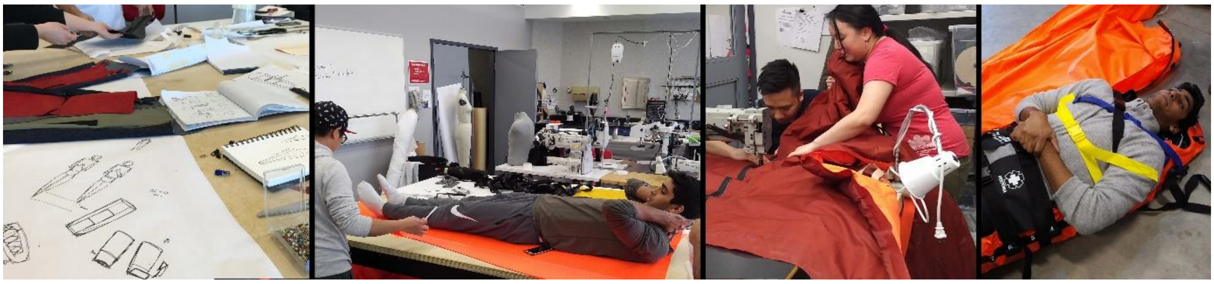

Figure 3. Iteration 1 - Small scale and full-scale prototyping of the Burrito: ideation development, anthropometrics, prototyping, and integration with medical equipment (image credits: Alisa Yao)

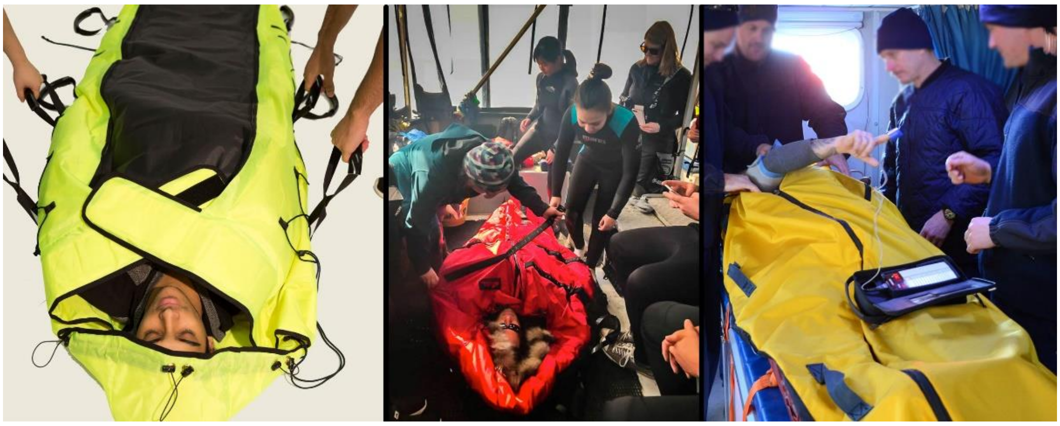

Figure 4. left: Thermal rewarming projects: left peri-urban SAR (2017) (credit: Alisa Yao), centre: Polar Burrito (2018) shown in field testing aboard a vessel during a snorkel safari (credit: Jeff Britnell), right ENIX (2019) for marine environments being field tested by the Coast Guard (credit: S. Phillips)

6 RESULTS, FINDINGS, AND INSIGHTS

Design education is a constantly changing field, with creativity a factor in pedagogy as well as practice. The specific project evaluation survey revealed insights on risk, laddering and expertise.
Risk: Thirteen responses were received for the project questionnaire (n=13 of 20, 65% response rate). All students responded that the project 'helped them grow as designers' with 77% of the students "strongly agreeing". Our enquiry into risk and expertise yielded interesting insights, in that 60% of students "agreed" with the statement that the project informed their willingness to take risks in their other design project, yet 23% were "neutral" and 15% "disagreed". In comparison, 93% of students "agreed" (of which 54% "strongly agreed") that the project informed their understanding of risk from the perspective of the users and the context (Figure 5).

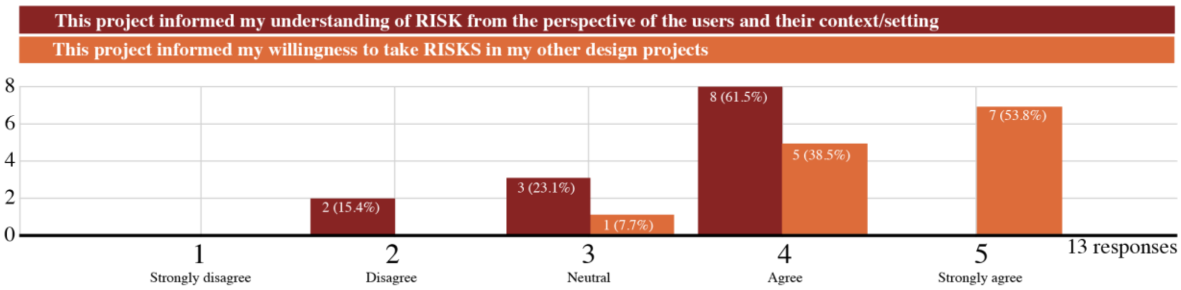

Figure 5. Student project questionnaire: Likert scale results on risk

Laddering: Another aspect of this project is the laddering cycle of 3 years. When asked how reviewing prior prototypes informed their design process, student responses focused on the value of reverse engineering and hands-on testing, both front-end analysis methods: "*...understanding why the previous year did what they did in terms of the last generation product was a great foundation to build upon. It evoked inspiration to push the previous boundaries and to find out what worked and what did not- to learn and improve on the next generation product."* Another student offered; *"By interacting with previous prototypes, we were able to discover problems (or great solutions) of that prototype's potential in that context...this allowed us to search for potential problems and test new ideas to resolve for our context."* Diving deeper into the project's approach, one student noted that they were able to integrate new knowledge "…*mostly by studying and testing the old product and comparing to the new prototypes to find out how to optimize usability, affordances and overall function*." The level of critical analysis was specific, with another student noting "…w*e could see the level of detail and overall scale we could expect and ... understand the product in a tangible way"* and another noted even more tangible elements of the design: "*…utilize similar closing techniques but iterate new solutions for a colder climate with increased variables that could limit the burritos success (cold, ice, wet etc.), this allowed us to build off previous prototypes closing system to understand what would be successful and not."*
Expertise: The programme focuses on critical thinking skills based on quantitative and qualitative research. Students review a range of secondary research sources (technical reports, scientific papers, patents, etc.) and learn skills to identify, access, communicate with and interview a range of experts.

The role of expertise is highlighted in this project due to the unknown context and the risk-level associated with the context. When asked of the importance of this aspect, 84.6% (11 of 13 students) strongly agreed it was important to their understanding. Students were also asked whether the project gave them skills or confidence in reaching out to experts with 23.1% strongly agreeing/46.2 % agreeing that they developed their skills through the project, while 38.5% strongly agreeing/46.2 %. This was echoed by one student's comment: "*Reaching out to experts and having interviews is really important to designers and for personal development. I feel I was already comfortable doing this but for those who may not have been, it would be an even more important experience to have.*" The mediation of expertise is a central challenge for many designers and therefore one we explored and supported. When asked, 92% of the students (11 of 12) indicated that the project contributed to their ability to compare and evaluate information obtained from different sources.

7 DISCUSSION & CONCLUDING THOUGHTS

This paper offers recommendations and perspectives on the notion of an expanded field of context for a future generation of design practitioners. The roles of risk and expertise were explored in depth with the student cohorts for the past five years. The area of risk analysis is essential in complex environments where uncertainty is key and new research suggests that there are discrepancies between what users declare as risk behaviour and what they do [9]. The findings with regards to expertise reinforced the value in developing skills and confidence in reaching out and in comparing and evaluating information from different sources, as expected. However, researching the role of risk yielded interesting insights. While the faculty saw the students take notable risks in the project based on the 'big' nature of the deliverables, the demanding research element, and the multiple points of reference outside their knowledge base, the student survey results didn't support this observation. Instead, we saw that the project helped them to understand risk, but that understanding of risk was informed through the perspective of the user and context.

The curriculum model is a general foundation in design as well as specialization. Held in high regard are the niche manufacturing industries in the region (technical equipment, adventure apparel, material innovation, survival gear, and emergent technologies). The industry-based Programme Advisory Committee (PAC) guides the programme objectives and the specific skills needed by students/graduates, as they reflect on the changing labour market. The PAC has responsibility and opportunity. As evidenced by the project described in this paper, the faculty aims for a balance of theory and practice founded in direct industry experience and worthy problems. As the programme is growing quickly, and successive years see larger cohorts, this may introduce complexities to this project and team structure and roles, but it may also provide opportunity for further expanding the fields of context.

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