PRODUCT INNOVATION THROUGH SOLAR DECATHLON INDIA
Sustainable Cooling Solutions for Retrofitting Residential Buildings

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Abstract: India's building stock is rapidly increasing, escalating cooling demands and energy use amid worsening heatwaves. Retrofitting at least 20% of existing buildings is essential for energy efficiency and public health. Integrating Heat Action Plans and retrofitting solutions is critical. The Product Division in the Solar Decathlon India 2023-24 Challenge focused on accessible, effective retrofit solutions for residential buildings. This paper provides an overview of the competition's structure, participant experiences, and outcomes, highlighting the impact of design thinking on innovation. The Division guided participants through a structured innovation process, with 15 multidisciplinary teams developing retrofit solutions for cooling needs in existing homes. The challenge sparked significant interest in sustainable innovation, with solutions including building envelope improvements, passive cooling techniques, and smart controls. Three teams filed for patents, and one attracted investor interest. Stakeholder feedback emphasised the need for enhanced financial modelling, problem understanding, and technical rigor. The pilot's success promises pathways for transformative innovation in the building sector for sustainable cooling and demonstrates the need and value of introducing product development into the academic coursework in architecture and engineering curricula.

Keywords: *Climate Adaptation, Product Development, Design Thinking, Innovation, Residential Cooling*

1. Introduction

India's building stock is rapidly increasing, exacerbating cooling demands and energy consumption in a warming climate (Behal, 2023) (Gupta et al., 2022). With residential sector floor area projected to grow by 6 billion m^2 over a decade (Kumar et al., 2019), the existing stock of inefficient buildings grows because of the lack of policy success and market uptake for decarbonising the building sector. There is a need to retrofit at least 20% of the existing building stock at a rate exceeding 2% renovation annually to bring us closer to net-zero by 2030 (IEA, 2022).

During April and May 2024, India experienced unprecedented temperatures exceeding 40°C for extended periods, causing severe health impacts and disruptions to daily life and education (World Weather Attribution, 2024). Delhi, for example, had some areas recording 52.9°C (Jacob, 2024). Night-time temperatures, which have increasingly exceeded 25°C, are further compounding the health risks and affecting overall quality of life (Bose, 2024). The escalating frequency and intensity of heatwaves in India have prompted the development of Heat Action Plans (HAPs) at various administrative levels to mitigate their adverse impacts (Murthy & Mathew, n.d.) (Ministry of Earth Sciences, 2023), which include public education, establishment of cooling centres, and infrastructure improvements like heat-resistant building materials, and strategies like cool roofing technologies (Murthy & Mathew, n.d.) (Hussain, 2023) (Valiathan Pillai et al., 2023). Attention is needed for the existing building stock, approximately 80% of which is residential, where nighttime cooling is a primary concern. Over 40% of residential building energy use is from fans and air-conditioners (Shukla et al., 2015). Retrofitting residential buildings is needed for enhancing resilience, reducing greenhouse gas emissions, and reducing peak electricity loads.

Over 60,000 architecture and 500,000 engineering students graduate annually from courses connected with the building sector without any education on addressing climate change (Manu et al., 2010) (Manu et al., 2017). Solar Decathlon India (SDI), an annual competition was launched to respond to this gap in education by creating a pedagogic shift. It challenges undergraduate and postgraduate students to create innovative, net-zero solutions for India's building sector. Student teams partner with the industry to work on live projects and also influence industry practice. SDI is now the world's largest net-zero building challenge, with over 6,000 students from over 300 institutions collaborating with over 270 partners in the building industry.

The Solar Decathlon US, which spawned SDI, conducted impact evaluations in 2012 and 2023 that found that hands-on experience for the participants was crucial for understanding complex concepts in energy efficiency and renewable technologies. Over 70% of the participants of Solar Decathlon US went to be employed in clean energy fields demonstrating the success of the capacity building aspects of the programme (Lockheed, 2012) (Opinion Dynamics, 2023). Considering this and the need for easy to install DIY style products that aid energy efficient cooling in residential spaces, the SDI organisers introduced a Product Division in addition to the five existing Building Divisions in 2023-24. While the Building Divisions

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focussed on helping students learn the integration of best practices and cutting-edge technologies for new construction of net-zero buildings, the Product Division focussed on helping them learn innovation of new products needed for existing residential buildings. The Product Division challenged student teams to 'make' retrofit solutions to improve cooling performance in residential buildings, where the solution would be implementable by the resident with minimal assistance e.g. use electrical technician, carpenter, or completely Do-It-Yourself (DIY). The challenge was to develop solutions that are not only effective but also accessible and easy to install. Whether through improvements in building envelopes, passive cooling methods, or enhanced equipment and controls, solutions had to be deployable as off-the-shelf products. Each solution had to be developed into a prototype and tested for reduced cooling loads, energy consumption and user acceptance.

This paper summarises the experiences and learnings of the pilot run of the Product Division. The method section outlines how the Product Division was conceptualised and executed. The results section summarises the outcomes in terms of participation, product solutions developed, and feedback from stakeholders. The significant contribution of the paper lies in demonstrating how a structured competition like SDI's Product Division can engage students to innovate scalable solutions for real-world problems in the building sector and the importance of product development as a part of education for the building sector, including architecture. The paper depends on the data provided by the students in their reports through the competition and is therefore limited by the fact many teams did not provide comprehensive data quantifying the energy savings they were able to achieve through their innovations. It is also limited in its inclusion of certain technical specifications of student innovations as multiple teams are in the process of applying for patents which will be hindered with the inclusion of such specifications in the public domain.

2. Method

This section summarises how the Product Division was rolled out and executed over the 9-month period.

2.1. DESIGN THINKING APPROACH

The design thinking approach was employed in terms of the four stages: developing empathy with end-users and defining problem statements, ideating solutions, prototyping, and testing (Ogilvie & Liedtka, 2019). Participants were asked to follow the design thinking approach by dividing the 9-months into 4 stages, each with its own Deliverable (see Figure 1).

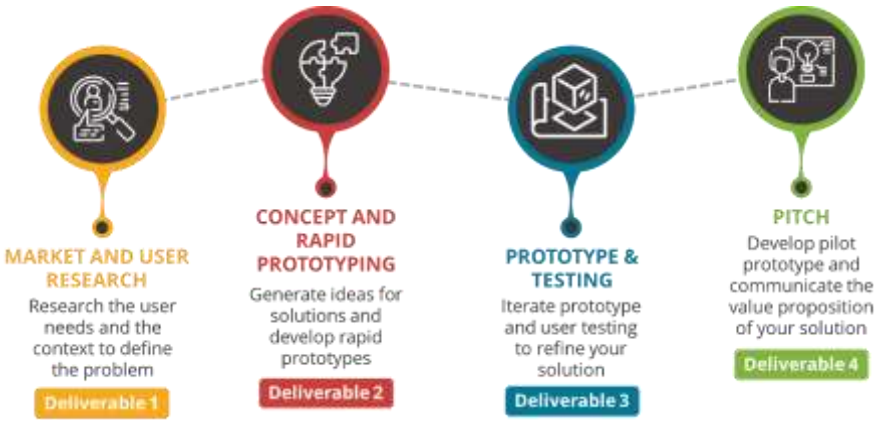

Figure 1: The 4-stage process of product development aligned with the design-thinking approach

2.2. ELIGIBILITY AND TEAM FORMATION

SDI required that all teams participating in the Product Division be multidisciplinary, with at least one student specialising in architecture/building science and another in engineering. Postgraduate and undergraduate students from Indian institutions could form a team. Each team could have a minimum of 5 and a maximum of 15 students and was required to have one faculty mentor acting as the primary Faculty Advisor. Teams could have multiple Faculty Advisors providing subject matter expertise and mentorship.

2.3. INDUSTRY PARTNERS

Teams were required to partner with the industry. Industry Partners offered critical resources such as materials, equipment, technical support, and access to testing facilities. They played a pivotal role in guiding teams through regulatory frameworks, market dynamics, and product lifecycle considerations, ensuring solutions were not only innovative but also commercially viable.

2.4. FACILITIES AND EQUIPMENT

Teams were encouraged to leverage resources available within their academic institutions, including workshops, laboratories, and design studios. Additionally, SDI compiled and distributed a comprehensive directory of fablabs and maker

spaces located across various Indian cities. Teams could approach these labs and maker spaces to access specialised tools, equipment, and fabrication facilities.

2.5. SUPPORT STRUCTURE

To equip the teams for the duration of the competition, SDI provided several resources. These included self-learning modules to build a foundational understanding the basics of net-zero buildings, access to expert mentors from the industry, and expert led webinars. Expert mentors from the industry were a part of the SDI Technical Resource Group (TRG) and specialised in human-centric design and prototype development. These mentors were available to provide guidance throughout the iterative process of conceptualisation, design refinement, and prototype testing. The webinars covered essential topics such as user-centred design research, market research methods, prototyping techniques, cooling performance evaluation protocols, and user testing strategies, before each of the 4 Deliverables.

2.6. TEN CONTESTS AND THEIR REQUIREMENTS

SDI established ten contest areas as facets of product development and market readiness. Together, these contest areas helped the participants work towards a robust solution. The contest areas also provided the jury criteria for evaluating a variety of solutions for the problem. The contest areas were as follows:

1. **Value Proposition:** Crafting persuasive narratives for end-users and potential investors, highlighting tangible and intangible benefits.
2. **Novelty:** Assessing the uniqueness and potential intellectual property of the solution relative to existing alternatives, emphasising technological innovation and competitive differentiation.
3. **Target Market:** Identifying and quantifying market opportunities, including market size, demographics, and adoption projections across diverse user segments.
4. **User Desirability:** Conducting comprehensive user research to gauge product appeal, usability, and satisfaction, leveraging methodologies such as surveys, interviews, and focus groups.
5. **Cooling Performance:** Quantifying and demonstrating the efficacy of cooling solutions through rigorous performance testing protocols, comparing against established benchmarks and baseline conditions.
6. **Co-benefits:** Identifying and validating additional benefits derived from the solution beyond core cooling performance, such as improved health outcomes, energy efficiency gains, and enhanced user comfort.
7. **Ease of Installation:** Simplifying installation processes to ensure user-friendly implementation, supported by clear instructional guides and intuitive design features.
8. **Technical Feasibility:** Assessing the technical robustness and scalability of the solution, evaluating compatibility with existing building infrastructure and potential for widespread adoption.
9. **Financial Feasibility:** Analysing the economic viability of the solution through cost-benefit analyses, pricing strategies, and profitability projections, informing stakeholders on investment attractiveness and market positioning.
10. **Go-to Market Strategy:** Developing a comprehensive business plan aimed at maximising commercialisation prospects and stakeholder engagement.

2.7. EVALUATION

The 4 Deliverables (see Figure 1) covered the progression from initial market research and concept prototyping to final prototype testing and documentation, with each stage involving specific guidance and feedback to refine the product and its presentation.

- Deliverable 01 - Market and User Research Report: This is the initial stage where teams gather and describe the context, user research, description of the people they are designing the product for, problem definition, objectives, and success metrics, as well as a project summary and a team summary.
- Deliverable 02 - Concept and Rapid Prototyping Report: This is an interim submission to demonstrate the team's progress towards completing the project. For this Deliverable teams develop and test initial design concepts, documenting their iterative process and prototypes.
- Deliverable 03 - Prototype Test Report and Product Ad: This is an elimination round. Teams create a functional prototype and test it against prescribed performance criteria, documenting their findings in a Prototype Test Report. They also submit one compelling product ad in a poster format.
- Deliverable 04 – Documenting the final Prototype: This is the final submission stage where in the first-round teams submit a comprehensive final report, including detailed documentation of their product's performance and potential and a step-by-step installation video for their prototype. During the second round of submissions, they submit a 3-minute movie, a poster, and two presentations.

After the submission of each Deliverable teams received feedback on their work, including suggestions for areas for development or investigation. Deliverable 3 was an elimination round, and 6 finalist teams were selected. Following Deliverable 3, reviewers conducted an on-site evaluation of the prototype and a meeting with the team. They had the opportunity to examine the installed prototypes, witness their functionality, and provide additional insights. The 6 finalists submitted Deliverable 4, where they presented their final report, refined prototypes, and a verbal presentation during the

SDI Finals event. Deliverable 4 was reviewed by 3 jury members with expertise in the areas of: building science, cooling performance, and calculations to assess the technical merit of the products, ensuring they met the necessary cooling performance requirements; innovation and product development to evaluate the human-centric approach employed by the teams in creating their solutions, and; business and manufacturing of building products to assess scalability and market integration of the solutions proposed.

2.8. STAKEHOLDER FEEDBACK

At the end of the challenge year, the SDI organisers conducted a meeting at the SD finals 2024 event to get feedback on the product division from different stakeholders including jury members and reviewers, industry experts, advisors to SDI, and Faculty Advisors to the teams.

3. Results

This section covers the outcomes and findings. It includes participant demographics, the breadth of proposed solutions, an examination of the evaluation by the jury, and the stakeholder feedback.

3.1. PARTICIPATION

In the 2023-24 Challenge of SDI the Product Division had 15 teams made up of 158 students guided by 30 Faculty Advisors. The participation was diverse with 70 participants (37%) from well-known institutions such as Indian Institute of Technology (IITs) and National Institute of Technology (NITs), and the remaining from lesser-known institutions, spread across the country in Tier 1, Tier 2, and Tier 3 cities. Tier 1 cities i.e. Delhi, Mumbai, Hyderabad, Bangalore, and Chennai accounted for 57% of the participants. Tier 2 cities such as Jaipur, Nagpur, Patna, and Rourkela accounted for 22% of the participation, and Tier 3 cities such as Erode, Ropar, Aligarh, Pilani, etc made up 21%. This distribution shows the substantial concentration in metropolitan areas and developed urban centres, but also a broad geographic reach (see Figure 02).

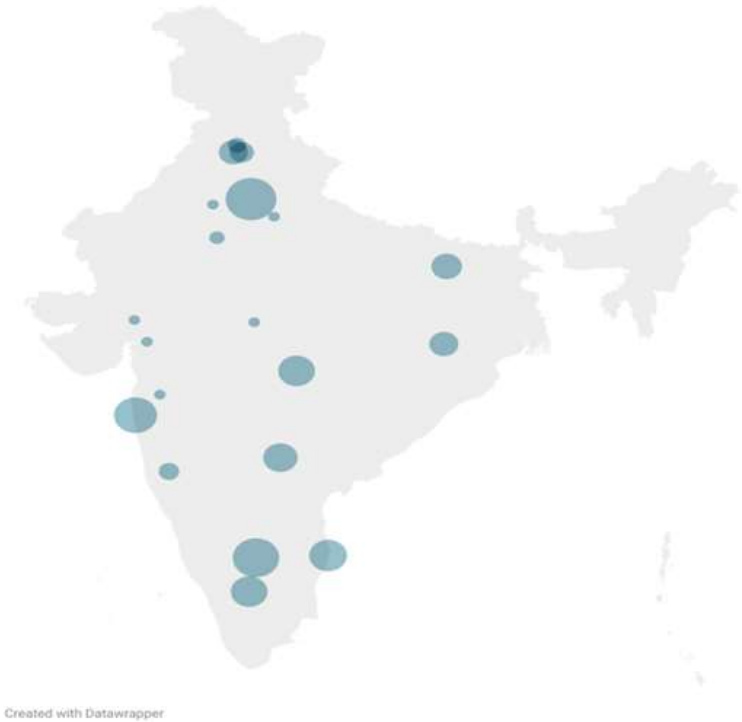

Figure 02: Geographical spread of participation in the Product Division

The competition had a male-majority participation, with males constituting 67.29% and females 32.71%. This gender distribution is indicative of the broader trends in STEM fields, where male participation often exceeds female participation (Stewart-Williams & Halsey, 2021). Undergraduate students formed the majority with over 70% participation, and the remaining 30% were postgraduate students. Many teams were multidisciplinary with students from Architecture, Mechanical Engineering, Electrical Engineering, Civil Engineering, Chemical Engineering, Electronics and Communication, Product Design, and Computer Science. However about 70% of the students were from engineering programmes.

The diversity in participation across various institution types, geographical areas, and academic backgrounds underscores a nationwide interest in sustainable innovation and product design. The significant majority of undergraduate participants suggests robust academic involvement at the foundational level.

3.2. SOLUTIONS

The organisers anticipated solutions in a range of domains, including building envelope, dynamic shading, passive cooling techniques, active cooling, appliances, and smart controls. Solutions could also overlap across these domains. Solutions were expected to be original, technically and financially feasible, functional, and improve cooling performance for occupants.

The progress funnel of the competition showed that of the 15 teams that participated, all 15 submitted Deliverable 1, 12 teams submitted Deliverable 2, and 09 teams submitted the Deliverable 3. Their solutions included development of new materials for insulation and blinds, movable shading assemblies, evaporative and hybrid cooling devices, radiant cooling systems, and portable air conditioners. The examples included here are intended to give the reader an understanding of the range of solutions the student teams innovated. They do not comprehensively document each solution or are meant to provide a comparative analysis of all solutions against one another or the existing cooling solutions in the market.

Two teams proposed prototypes using new materials developed by them. One team proposed Mycelium Ceiling Panels (See Figure 03) that uses mycelium and organic waste to create ceiling panels that provide insulation and cooling (Team Archtic-Air, 2024). This prototype focussed on providing relief to occupants of flat roof residences during summer months. Another team developed insulating blinds made from sugarcane bagasse and clay (Team Svasthya, 2024).

Figure 03: Mycelium Ceiling Panel developed by Team Archtic-Air (Team Archtic-Air, 2024)

Figure 04: Hybrid system featuring terracotta for dehumidification developed by Team Solstice (Team Solstice, 2024)

Two teams developed advanced cooling technologies in the form of a phase change material-based radiant cooling system that optimises energy usage and thermal comfort and a portable cooling system that integrates reflective bubble wrap aluminium curtains to reduce solar heat gain (Team Resolution, 2024). The portable cooling system addresses the problem of having multiple air conditioners and installation, maintenance, aesthetic issues of outdoor units of split-ACs.

Three teams developed window- integrated cooling solutions in the form of DIY modules for passive cooling, using modified scissor lifts and custom gear chains offering adjustable cooling (Team Navya, 2024), an energy-efficient window design integrating air purification and evaporative cooling using cellulose pads for enhanced cooling (Team Zenith 2.1,

2024), and a panel of wind catchers with an integrated sprinkler system that uses evaporative cooling and the venturi effect to provide cooling through minimal input of energy.

Two teams proposed innovative hybrid systems; one that combines desiccant technology and terracotta materials (See Figure 04) for dehumidification and cooling as an affordable and sustainable solution (Team Solstice, 2024) and another that uses thermoelectric modules and solar power for efficient cooling of security cabins (Team Tejasvi, 2024). Both teams focussed on developing solutions to serve vulnerable parts of the general population such as low-income families in small apartments and security guards working out of small security cabins. Of these 9 teams, 6 were selected as finalists who further developed and tested their prototype for the final deliverable.

Figure 05: Portable air conditioning unit developed by Team Resolution (Team Resolution, 2024)

Team Resolution, made up of 11 architecture students, one product design student, one engineering student, and one design student, led by IES College of Architecture from Mumbai was the winner of the Product Division in 2023-34. During their comprehensive background and user study, the team recognised the substantial portion of the Indian AC market dominated by household consumers and aimed their retrofit product at the urban demographic. They had interviewed over 150 households and identified redundancy of multiple units in an apartment as a waste of resources, and problems with installation and maintenance of outdoors units hung outside in precarious positions. Their product named COOALA, a 1-ton water-cooled machine has no outdoor unit, can be rolled from room to room as needed, and eliminates holes and pipes through walls (See Figure 05). It uses temporal heat dissipation principles with a dual compressor cycle and matches the cooling performance of a typical 1.5-ton room AC. COOALA features a dual compressor mechanism: a primary 1-ton refrigerant compressor for removing heat from the room in to cooling liquid in a tank and a secondary compressor for moving the heat from the tank to the outdoors. Their tests showed that it maintains a comfortable temperature range of 22°C-28°C. Team Resolution's next steps include developing user-friendly UI/UX interfaces, integrating advanced sensors, HEPA filters, and inbuilt mosquito repellents (Team Resolution, 2024).

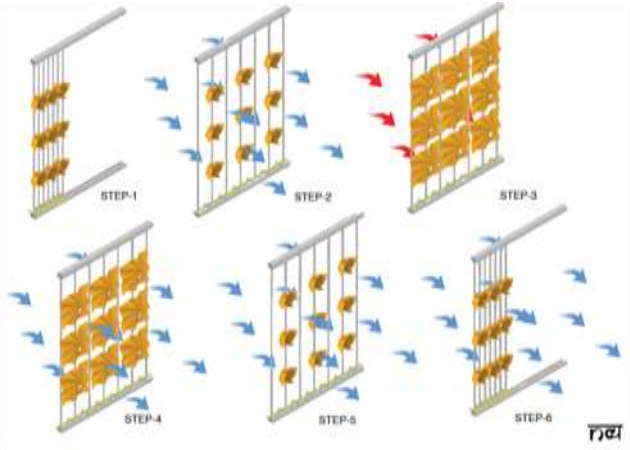

Figure 06: Illustration showing BLOOM by Team Navya (Team Navya, 2024)

Team Navya, a group of eleven architecture students and four multidisciplinary engineering students from Visvesvaraya National Institute of Technology (VNIT) in Nagpur, developed 'Bloom', a flasher-based dynamic cooling prototype designed as an alternative to traditional passive cooling technologies (See Figure 06). This modular, DIY kit allows users to install the cooling system themselves, achieving an average temperature differential of 3°C post-installation. The team validated

Bloom's efficacy through extensive baseline measurements taken in Chitaroli, a densely populated and heat-stricken area of Nagpur. The team reported that they monitored dry bulb temperature (DBT), internal air temperatures, relative humidity, and air velocities over 102 days at two sites including pre-installation measurements to establish baselines. Their prototype demonstrated a 93.5% airflow rate, reducing the need for additional cooling appliances. The team aimed to make Bloom affordable. It has a retail price of Rs 16,000 per unit with operational costs of Rs 79 per month. Bloom faces limitations in extreme weather conditions, which could lead to malfunction. The product's design includes advanced smart sensors and automated, self-propelled motors that adjust to surrounding temperatures, providing both comfort and energy efficiency, and can integrate with IoT systems, allowing users to control and manage the device via smartphones and other electronic devices. Team Navya was the runner up of the Product Division in the SDI 2023-24 Challenge (Team Navya, 2024).

3.3. JURY EVALUATION

While teams had performed well in the 'Ease of Installation' and 'Cooling Performance' contest areas in Deliverable 3, this shifted in the submissions by the finalist teams in the Deliverable 4, where jury scores indicate that the teams performed well in the 'Target Market and User Desirability' and 'Ease of Installation Contest Areas' and struggled with the 'Cooling Performance' and 'Financial Feasibility' contest areas. Though some teams demonstrated adaptability by addressing weaknesses from Deliverable 3 and significantly enhancing their market alignment and strategic planning by Deliverable 4, other teams struggled to overcome persistent challenges. The shifts in scores reflect iterative development and strategic adjustments as teams navigated through the competition stages.

In Deliverable 03, the feedback from the jury indicates a wide variety of quality in the submissions. Teams received praise for innovative ideas and detailed market studies but were critiqued for lacking clarity, specificity, and thoroughness in their propositions and feasibility analyses. The jury's comments suggest that focusing on detailed, realistic, and market-aligned strategies would significantly enhance the quality of future submissions.

A plot of the scores given by the jury for the 10 contest areas for 6 finalist teams is shown below (see Figure 07). Each contest area had a maximum score of 10. The scoring rubric of SDI was given to the Jury for the point scale of 1-10 (Solar Decathlon India, 2023), and a score of 5-6 is given when the work meets the minimum expectation of quality. Of the 9 teams that submitted the third Deliverable the team with the highest evaluation had an average score of 62 out of 100 and the team with the lowest evaluation had a score of 19 out of 100. The six teams with a score of 31 or more were selected as finalists.

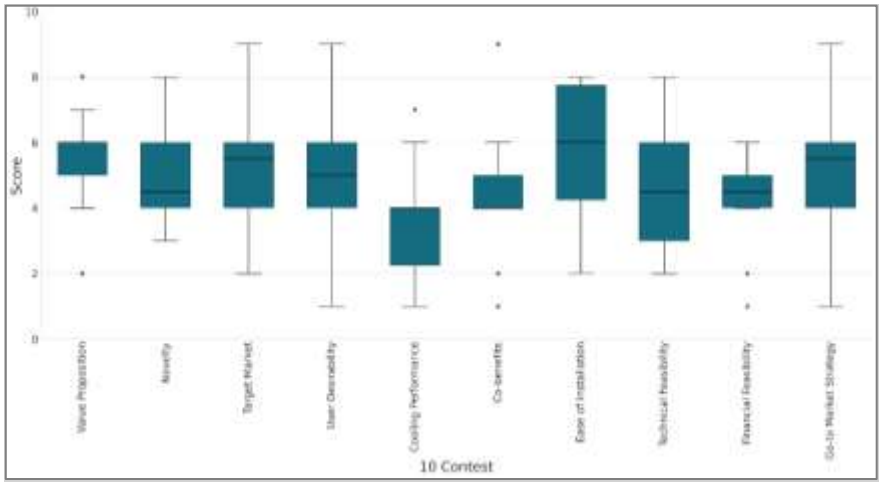

Figure 07: Jury scores for the 6 finalist teams across the 10 contests in Deliverable 4

High Scoring Contest Areas

- Value Proposition: Median score of 6. Teams did well explaining the value of their products, especially in terms of sustainability and cost-effectiveness.
- Ease of Installation: Median score of 6. Detailed guides and DIY approaches were praised. Teams also submitted videos showing the ease of installation.

Average Scoring Contest Area

- Target Market: Slightly above-average median score. Teams generally defined their target markets well. This included direct interactions with potential customers and detailed documentation. Submissions were weak on quantitative analysis of market size and linking product features to user requirements.

Mixed Scoring Contest Areas

- User Desirability: Scores varied. Teams understood user needs but needed more data to support user satisfaction and a detailed competitive analysis.

- Go-To-Market Strategy: Scores varied. Teams outlined marketing strategies but needed more specific actionable details, success metrics, and a clearer understanding of the competitive landscape. There was a need for a detailed explanation of market positioning and expected market size.

Low Scoring Contest Areas

- Cooling Performance: Median score of 4. Teams presented methods for evaluating cooling performance but needed to improve on describing thermal comfort and effectiveness. Many teams failed to adequately describe thermal comfort and the actual performance of their products in providing cooling and provided vague descriptions or insufficient data to back up their claims about cooling performance. This was a common point of critique.
- Co-benefits: Median score of 4. While teams highlighted additional benefits like improved air quality and energy savings, their documentation and scientific rigor for these was weak. Some reports listed product features instead of true co-benefits.
- Financial Feasibility: Low median score with concerns about lack of detail and clarity. Teams needed to provide better cost breakdowns, consider alternative financial scenarios, and address scalability, long-term sustainability, and financial risks.

3.4. STAKEHOLDER FEEDBACK

The feedback from the stakeholders highlighted areas where the Product Division worked well and areas for improvement. The feedback was provided in the context of the objectives for this division: Students learn to innovate solutions that 1) perform, 2) have been tested with prototypes, 3) are desired by the users, and 4) have a target market. The summary of the stakeholder responses is divided into three categories focussing on strengths, challenges, and recommendations.

Strengths:

- The Competition Guide was appreciated for its clarity. The learning opportunities across the 9 months and four Deliverables along with the space for out of the box thinking worked well.
- The expert led webinars on design thinking were appreciated and provided more targeting learning than the self-learning modules.

Challenges:

- Faculty reported that they had difficulty in assembling teams with the right mix of skills and expertise across various contest areas.
- None of the teams managed to deliver a tangible product in the 9-month timeframe. Jury and reviewers reported that while several ideas were interesting, they had not been taken far enough with technical rigour and testing.
- Reviewers reported that teams need to better understand the problem and market needs. They also noted that teams struggled with financial modelling and articulating the "why" behind their solutions.

Recommendations:

- There were significant disparities in the financial resources allocated for prototyping across different teams. There was a recommendation to provide some funding to ensure a level playing field.
- Reviewers suggested expanding the scope of the competition to include broader product ideas beyond the current focus on cooling solutions.
- There were suggestions that product designers should be part of the teams.

Towards the end of the challenge, through the encouraging comments that the teams received from the industry experts at the SDI Finals, three teams are in the process of applying for patents, and one team has investors interested in their product.

4. Conclusion

The introduction of the Product Division within the Solar Decathlon India 2023-24 Challenge proved to be a successful pilot. Throughout its 2023-24 run, the Product Division engaged a diverse set of undergraduate and postgraduate students from across the country and equipped them with the knowledge and resources needed to explore innovative retrofit solutions for residential buildings. As a result of the process, the participating students became aware of the possibilities for innovation and problem solving in the buildings sector that lie outside the traditional domains of architecture and engineering.

By encouraging multidisciplinary participation beyond the typical boundaries of architecture and engineering the challenge exposed the students to real world problems, methods of developing a deeper understanding of problems related cooling needs and the fundamentals of sustainable cooling solutions and tapped into their innovation and entrepreneurial spirit. This is also evidenced by the three participating teams who have filed for patents for their innovations.

The success of the first edition of the Product Division shows potential for broader implementation of this approach in the education of design and architecture. For the second edition of the Product Division, the SDI organisers have increased the intake of participating teams to 24. The organisers are also offering scholarship grants to select teams after the second Deliverable and all finalist teams after the third Deliverable to help them create better prototypes.

Such product challenges expose students to a method of developing empathy for the users, ideating, making prototypes, testing, and reiterating for problem-solving. This method is possible for products which are easier to make and test, while this process is very difficult to implement on buildings which have a much longer production-and-use cycle. This is perhaps the reason why most architects become skilled professionals after about two decades of practice. Integrating such product development challenges into the academic coursework at undergraduate and postgraduate levels can help our future generation master this method before they enter the profession. It will also create pathways for innovation and entrepreneurship, opening additional career opportunities.

The first edition of the Product Division of Solar Decathlon India has laid a strong foundation for scalable and transformative innovation in the building sector, especially as it relates to retrofitting existing buildings, and developing sustainable cooling solutions in a warming world. It has also demonstrated the need and value of collaborative working that involves a variety of disciplines to solve complex problems. There is tremendous potential for innovation and product development to accelerate India's transition towards net-zero and climate-resilient buildings as well as for global efforts in combating climate change.

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