



# Empowering digital innovation in SMEs: Experimental evidence from design sprint innovation contests

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## ABSTRACT

Innovation contests, such as hackathons and other time-bound competitions, foster innovation by promoting creative problem-solving, interdisciplinary collaboration, and rapid idea development. This study examines whether a Design Sprint-based contest can encourage SMEs to adopt design approaches. Conducted as a randomized controlled trial (RCT) with 190 SMEs across seven European countries, the experiment assessed the impact of a three-day contest on SMEs' knowledge, attitudes, and intentions regarding design methodologies. Results show a 19 % increase in SMEs' understanding of the Design Sprint methodology and a 12 % improvement in their ability to implement it. However, these gains did not translate into significant changes in attitudes or intentions to adopt design practices, highlighting persistent structural barriers such as resource constraints, risk aversion, and skepticism. While the intervention reduced perceived obstacles like insufficient expertise and information, it failed to address broader organizational challenges. These findings suggest that innovation contests can cost-effectively transfer design knowledge and lower adoption barriers but require sustained support to drive lasting organizational change.

## 1. Introduction

In today's fast-evolving digital economy, the survival and growth of SMEs depend on their ability to innovate. However, innovation is not solely driven by expensive research labs or cutting-edge technologies – it often begins with something more fundamental: effective (digital) design (Gao and Hands, 2021; Landoni et al., 2016; Mortati and Villari, 2016). While *Design Thinking* (DT) is increasingly recognized as a competitive advantage (Johansson-Sköldberg et al., 2013; Magistretti et al., 2022), many SMEs struggle to implement structured design practices (Fischer et al., 2019; Gulari and Fremantle, 2015). Since design is largely an “experience good” (Acklin, 2013), its value often becomes apparent only after successful application. This paradox is particularly relevant for SMEs, where limited resources and expertise hinder innovation despite clear growth opportunities (Franzò et al., 2023).

*Design Sprints* – structured DT applications for rapid digital product development – offer a promising approach for resource-constrained SMEs (Magistretti et al., 2020). Open Innovation (OI) research also

highlights how external collaborations, such as innovation contests, can bridge SMEs' knowledge gaps (Landoni et al., 2023). Building on these insights, this study investigates whether a Design Sprint-based innovation contest can foster DT adoption among SMEs.

Through a randomized controlled trial (RCT) across seven European countries, we examine how participation in a three-day contest impacts three key dimensions: SMEs' understanding of DT and Design Sprints, their attitudes toward design methods, and their willingness to implement them. Our research assesses the short-term effects of this intervention on firms' design capabilities and readiness to embrace DT approaches.

Findings reveal that participating SMEs significantly improved their DT knowledge, particularly regarding the Design Sprint methodology. However, these knowledge gains did not lead to statistically significant changes in attitudes or intentions to adopt DT practices. This suggests that while innovation contests enhance awareness and knowledge, deeper structural barriers hinder immediate adoption.

Our study contributes to OI and DT literature in three ways. First, it

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provides the first RCT-based evidence on Design Sprint contests' effectiveness in enhancing SMEs' DT knowledge and readiness. Second, by analyzing small firms in diverse European contexts, it highlights the practical challenges and opportunities of design adoption in resource-constrained settings. Third, the findings offer actionable insights for policymakers and innovation intermediaries aiming to promote SME innovation through scalable, cost-effective programs like innovation contests.

## 2. Theoretical framework

### 2.1. From open innovation to innovation contests

The concept of OI has become a key paradigm in innovation management over the past two decades. First introduced by Chesbrough (2003), OI refers to "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation" (Chesbrough et al., 2006, p. 1). Unlike traditional closed models, OI recognizes that valuable ideas originate both inside and outside firm boundaries. Initially targeted at innovation managers and practitioners, OI has since been academically grounded through various theoretical frameworks, including resource-based views, behavioral theory of the firm, learning theory, evolutionary theory, dynamic capabilities, and absorptive capacity (Capone, 2016; Bertello et al., 2024).

OI processes are categorized based on knowledge flow direction (Gassmann and Enkel, 2004): inbound, outbound, and coupled OI. Inbound OI involves acquiring external knowledge from sources like suppliers, customers, competitors, and universities to enhance internal innovation. This requires absorptive capacity (Cohen and Levinthal, 2000) – the ability to scan, assimilate, and apply external knowledge. Outbound OI entails externalizing knowledge through voluntary disclosure, facilitated by desorptive capacity (Lichtenthaler and Lichtenthaler, 2010), where firms share insights via publications, patents, or digital platforms to build networks, attract partners, and create business opportunities. Coupled OI integrates both approaches, requiring firms to manage bidirectional knowledge flows effectively.

External knowledge search is central to inbound OI and typically measured along two dimensions: search breadth and search depth (Carrasco-Carvajal et al., 2023). Search breadth reflects the number of external sources used (e.g., suppliers, customers, universities, competitors), while search depth indicates the extent of engagement with these sources. Laursen and Salter (2006) introduced these constructs, demonstrating that search breadth follows an inverted U-shaped relationship with innovation performance – excessive external searching leads to diminishing returns. Findings on search depth are more nuanced, varying by innovation type (product vs. process) and contextual factors such as resource constraints and knowledge availability (Garriga et al., 2013; Huang and Rice, 2013). Some studies suggest diminishing returns for deep search (Laursen and Salter, 2006), while others highlight consistently positive effects (Greco et al., 2016).

SMEs increasingly adopt OI practices (Kraus et al., 2020), particularly inbound activities. Studies show SMEs prioritize external knowledge sourcing and collaboration over outbound strategies like licensing or venturing (van de Vrande et al., 2009). Although large firms engage in more OI activities overall, SMEs exhibit a higher intensity of OI relative to their size, making them more dependent on external knowledge flows (Spithoven et al., 2013).

While OI's positive effects on firm performance are well established, SMEs face distinct challenges. Their flexible structures and fast decision-making processes provide advantages (Dubouloz et al., 2021; Dufour and Son, 2015), yet they encounter substantial internal and external barriers (Brunswicker and Vanhaverbeke, 2015; Usman et al., 2018). Internal constraints include financial and human resource limitations, time shortages, and cultural resistance, such as the "not-invented-here" syndrome (hesitation to use external knowledge), the "not-shared-here"

syndrome (reluctance to share internal insights) (Burcharth et al., 2014), and the "tribe syndrome" (resistance to collaborating across differing value systems) (Dubouloz et al., 2021). Organizational barriers stem from inadequate innovation management, lack of structured processes, and a short-term strategic focus that conflicts with long-term innovation efforts. External challenges involve difficulties in selecting and managing partners, trust issues, knowledge transfer risks, regulatory burdens, and market uncertainties. These barriers vary in intensity based on firm size and innovation stage (Dubouloz et al., 2021).

The SME–external knowledge relationship embodies a "resource paradox" (Franzò et al., 2023, p. 3): while SMEs need external knowledge to stay competitive, they often lack the resources to access and utilize it effectively. SMEs recognize the necessity of diverse innovation methods to meet evolving customer demands and avoid competitive disadvantages (van de Vrande et al., 2009), yet resource constraints hinder their ability to act. Innovation contests offer a solution by facilitating OI adoption, bridging SMEs' knowledge gaps while minimizing resource strain (Landoni et al., 2023). These contests attract diverse expertise and serve as crowdsourcing platforms, enabling participants to contribute insights across multiple innovation stages (Soñita-Drączkowska et al., 2024). Historically, governments and firms have leveraged contests and prizes to address complex societal challenges and stimulate innovation (Terwiesch and Xu, 2008). Beyond generating solutions, these competitions provide intangible benefits, such as networking, skills development, and community building, while increasing awareness of industry challenges and best practices (Doppio et al., 2021). The European Commission actively supports this approach, encouraging innovation agencies to explore contests as SME support mechanisms, particularly within Horizon 2020 initiatives (Doppio et al., 2021).

### 2.2. From design thinking to design sprint

The management and entrepreneurship literature has shown significant interest in design approaches over the past decade, with DT emerging as a particularly influential paradigm (Chouki et al., 2023; Johansson-Sköldberg et al., 2013; Micheli et al., 2019). DT represents a broad mindset and approach to innovation that extends beyond design practice itself. As a paradigm, its principles and tools are not only applicable to design but to a variety of challenges across industries. DT integrates intuitive and analytical thinking to address complex, "wicked" and "ill-defined" problems (Archer, 1979, p. 17; Rittel and Webber, 1973, p. 160), which conventional business tools fail to tackle (Hobday et al., 2012). Its creative and holistic nature fosters the reframing of problems, encouraging innovative solutions (Dell'Era et al., 2020).

From a theoretical perspective, DT aligns with dynamic capabilities, which enable firms to adapt to a changing business environment (Tece et al., 1997; Teece, 2007). DT has been conceptualized as a dynamic capability that enhances a firm's innovation capacity by: sensing new opportunities through understanding user needs; seizing opportunities through prototyping, testing, and developing solutions; and reconfiguring problems using new perspectives (Magistretti et al., 2021b). DT is valuable across all stages of innovation, from ideation to testing. Its structured approach to user engagement makes it particularly effective for co-creation, including idea generation, concept selection, prototype development, and user testing (Soñita-Drączkowska et al., 2024).

Within this interest in design approaches, the Design Sprint (Banfield et al., 2015; Knapp et al., 2016) is a specific application for digital products and services. Created at Google Ventures, the Design Sprint adapts DT principles to the needs of digital innovation, incorporating elements from agile development and lean startup approaches. While it shares core DT principles – such as user-centeredness, iteration, and prototyping – it provides a structured, time-bound format suited to digital product development (Magistretti et al., 2020). The methodology typically condenses the design process into a 3–5 day format focused on

rapid prototyping and testing, particularly useful for software and digital services, where quick validation is key. The Design Sprint approach excels in scenarios requiring swift validation of ideas, stakeholder alignment, and collaboration with external partners (Magistretti et al., 2021a). This is especially relevant in digital markets, where constant updates are needed based on market feedback, and traditional development methods are too slow for emerging risks and opportunities (Dell'Era et al., 2020).

Design Sprint's versatility has made it valuable across diverse contexts, from the United Nations and Lufthansa to LEGO (Volk-Schor and Wild, 2023). Two compelling cases illustrate its adaptability: Vodafone's market response strategy and Johnson & Johnson's pharmaceutical innovation process. Vodafone used Design Sprint in 2018 to create a new brand and business model when a low-cost competitor entered the Italian telecommunications market (Candi et al., 2023). By using sprints, they launched a fully digital telco provider in six months, compressing timelines while ensuring thorough concept validation. Johnson & Johnson's use of Design Sprint since 2017 in the highly regulated pharmaceutical industry highlights its potential to accelerate development while complying with regulations (Magistretti et al., 2021a). They created a "Sprint Playbook" to guide teams and ensure compliance while using sprints for rapid prototyping and anticipating regulatory restrictions.

Recent research suggests that Design Sprint is also adaptable to SMEs. According to Magistretti et al. (2020), SMEs face two primary challenges: solving usability issues in existing products and designing new concepts. SME characteristics affect Design Sprint applications: limited time, budget, and personnel influence the scope and team composition; and lacking specialized skills in areas like user research and UX design means SMEs often require external mentors. However, SMEs' streamlined decision-making structures allow them to adapt the Design Sprint process more quickly than larger firms. Additionally, an SME's innovation culture can influence their ability to fully leverage the methodology.

However, Design Sprint has limitations. The tight time constraints may cut short valuable user interactions that are crucial for deep understanding and effective solutions (Magistretti et al., 2021a; Volk-Schor and Wild, 2023). Moreover, user involvement can be costly and difficult, especially with hard-to-reach groups. Design Sprint also shares risks found in broader DT approaches (Liedtka, 2015; Micheli et al., 2019; Rösch et al., 2023). Its effectiveness can depend on the target organization's previous design experience, existing knowledge base, and design capabilities (Landoni et al., 2023). Companies with more established design practices may be better positioned to maximize Design Sprint's benefits than those with less design maturity.

### 3. Conceptual model

Building on insights from innovation contests as external knowledge sourcing strategies and leveraging the Design Sprint as a practical implementation of DT principles for digital innovation, we test the integration of these methodologies into a Design Sprint-based innovation contest (henceforth "Contest") to address the digital innovation

needs of SMEs. This format adapts the traditional Design Sprint methodology (Banfield et al., 2015; Knapp et al., 2016) within an OI framework, drawing inspiration from the hackathon model of intensive, co-located collaboration (Briscoe and Mulligan, 2014; Heller et al., 2023). Like hackathons, the initiative creates a time-bound, competitive environment where teams of solvers work in parallel to address real-world challenges submitted by seekers. This approach is particularly relevant since design is an "experience good" (Acklin, 2013), where confidence and adoption grow through direct exposure and observable outcomes. The design and rationale of this Contest are discussed in greater detail in Franzò et al. (2023).

The Contest aims to enhance design-related knowledge, attitudes, and intentions, potentially leading to the adoption of DT practices (see Fig. 1). DT adoption supports the development of digital innovation capabilities, as DT is recognized as a key driver of innovation. Specifically, DT contributes to the "digital innovation process" micro-foundation of firms' digital innovation capabilities, enabling them to sense and seize opportunities (Kroh et al., 2024, p. 4). This model aligns with Rogers' diffusion of innovations theory (Rogers, 2003), which suggests that knowledge acquisition and attitude formation precede adoption decisions. Rogers identifies three key types of knowledge: awareness knowledge (understanding what the innovation is), how-to knowledge (understanding how to use it), and principles knowledge (understanding how and why it works) (Rogers, 2003). Additionally, considering the *Theory of Planned Behavior* (Ajzen, 1985), the perceived obstacles within firms should be addressed, as these "non-motivational factors" (Ajzen, 1991, p. 182) affect perceived behavioral control and, in turn, influence both the intention to adopt and the actual adoption.

## 4. Research design

### 4.1. Research setting

We conducted a cross-country RCT to assess the effectiveness of the Contest across seven European countries. The Contest featured a three-day Design Sprint aimed at helping SMEs address design challenges related to their digital products or services. SMEs were recruited via an open call and assessed for eligibility. Eligible companies submitted briefs outlining design issues in their digital products, such as apps or software, focusing on enhancing usability, functionality, and overall user experience. University students and recent graduates with expertise in design and human-computer interaction were chosen as solvers, forming teams supported by experienced mentors. Prior to the Contest, solvers attended a half-day training session to familiarize themselves with the Design Sprint process, while SMEs shared detailed information about their challenges. Real end users were recruited to test the solutions developed during the Contest.

The Contest followed a structured three-day hackathon format. Over these three days, teams progressed through the five phases of the Design Sprint methodology. In the Map phase, teams established a shared understanding of the problem space through user journey mapping and collaborative problem definition. The Sketch phase involved individual ideation, with each team member drafting potential solutions. During

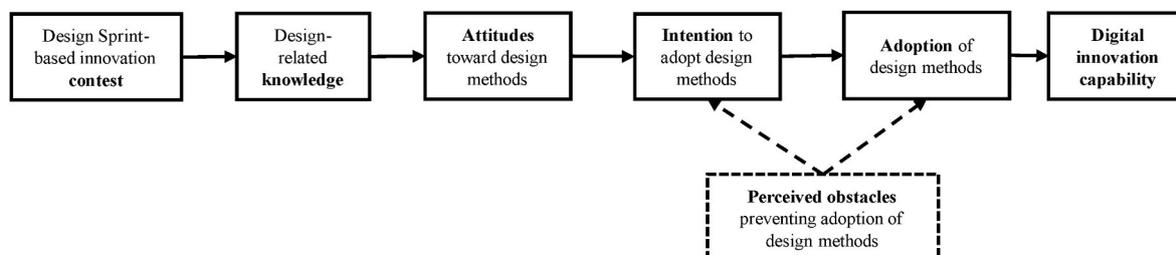


Fig. 1. Conceptual model.

the Decide phase, teams used structured decision-making techniques to select the most promising solution. In the Prototype phase, teams built a realistic version of their chosen concept. Finally, in the Test phase, teams conducted user testing with real end users to validate their solutions and gather feedback.

The teams' work culminated in a final plenary session where they showcased their innovations to an audience of SMEs, participants, and stakeholders. Deliverables included interactive prototypes demonstrating core functionalities, detailed mockups visualizing the user interface, mapped user journeys illustrating the end-to-end experience, and actionable guidelines tailored to each SME's specific context. This presentation phase not only demonstrated the solutions but also provided networking opportunities and increased visibility within the innovation ecosystem.

The impact of the Contest was evaluated using an RCT. SMEs were divided into treatment (participating in the Contest) and control groups. As detailed in Section 3, the primary outcomes measured were design-related knowledge, attitudes toward design methods, and intention to adopt these methods, which serves as a proxy for actual adoption. This adoption potentially enhances digital innovation capability, given DT's role as an innovation driver.

#### 4.2. Sample selection and descriptives

European innovation agencies recruited 208 SMEs from seven EU regions through an open recruitment campaign held between October 2020 and February 2021. Firms applied with a product/service and a related design problem (challenge), which were evaluated for suitability.

To be eligible, firms had to meet the EU SME definition (employing fewer than 250 employees and with a 2019 turnover below 50 million euros or a balance sheet total under 43 million euros) and provide details about the product/challenge they wished to include in the Contest, along with information about a reference person within the company. SMEs were assessed based on the proposed product or challenge, which had to be related to digital interfaces, such as mobile apps, web apps, or software. The suitability of the proposed product or challenge was evaluated using a scoring system based on five criteria: ease of use, ability to involve generic users, interactivity, innovative features, and the motivation and expectations outlined in the application. After this evaluation, 190 firms were selected for the study, which involved the administration of a baseline survey (BS), the provision of the Contest to a randomized treatment group of SMEs, and a follow-up survey (FUS). The FUS also included questions regarding the challenges companies might face when implementing the design approaches used during the Contest. This further analysis aimed to identify systematic adoption challenges independent of the intervention itself.

Table 1 shows the descriptive statistics for the sample responding to the baseline questionnaire. On average, firms participating in the challenge had nearly 20 employees; however, the median reveals that half of them were micro firms. Eight out of ten firms employed at least one

**Table 1**  
Firms and respondents characteristics.

	Mean	Median	SD	N
<i>Firm Characteristics</i>				
Employees	19.54	6.00	34.45	190
Employing a designer	0.82	1.00	0.38	190
Digital Design Experience	4.55	5.00	1.61	190
Suitability score	19.52	20.00	3.12	190
<i>Individual Characteristics</i>				
Male	0.73	1.00	0.44	190
Experience	15.81	15.00	8.77	165
Master's Degree	0.59	1.00	0.49	190

Note: the number of respondents may be less than 190 if there are no answers to specific items.

designer and reported a high (self-declared) expertise in digital design, with an average score of 4.6 on a scale from 0 to 7. The suitability score of the products and challenges submitted to the Contest ranged from 5 to 25, with selected firms averaging around 20 points.

Regarding individual participants, 73 % were male, with an average of 16 years of work experience, and 59 % held a university degree.

Fig. 2 shows the sectoral distribution among the selected SMEs. The "other services sector" was the largest category, comprising 33.68 % of participating companies. This sector is diverse, including membership organizations, personal service providers, and businesses focused on repairing computers and household goods, with computer and goods repair firms forming the largest subgroup. The second-largest sector was Information and Communication Technology (ICT), making up 29 % of the sample, indicating a strong alignment with the Contest's goals. Other sectors included human health and social work, professional and scientific activities, and manufacturing. Overall, the sectoral distribution reveals a clear dominance of service-oriented businesses, reflecting both the shift in the modern economy toward services and the pressing need for improved digital products and services in these sectors.

#### 4.3. Outcome variables

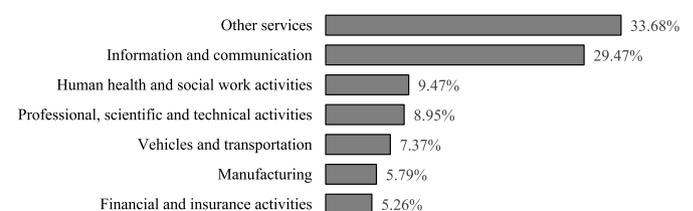
In Section 3, we outlined our focus on three key dimensions: design-related knowledge, attitudes, and intentions to adopt design methods. Table 2 provides the operationalization of these dimensions, detailing the construction of each outcome variable, the corresponding questions in the baseline and follow-up surveys (BS and FUS), the number of items, the measurement modality, the indexation method, and the reliability tests. To enhance comparability, all computed scores were normalized, with a minimum value of 0 and a maximum value of 10.

Following Rogers (2003), we address three critical types within the knowledge dimension: awareness (1.1. *General Design Knowledge*), which refers to understanding what the innovation is; principles knowledge (1.2. *Design Sprint Knowledge*), which pertains to understanding how and why it works; and how-to knowledge (1.3. *Knowledge to Implement Design Sprint*), which focuses on understanding how to use it properly.

The first variable (1.1) assesses respondents' self-perceived general knowledge about i) *User-Centered Design*, ii) *Design Thinking*, and iii) *Design Sprint*. The second indicator measures respondents' actual knowledge of the five specific phases of the Design Sprint. The third indicator gauges respondents' self-reported ability to perform a Design Sprint, specifically to implement its five phases. The first and third indicators are measured using Likert-scale questions analyzed via principal component analysis, while the second is assessed through quiz-like questions.

The second dimension (2. *Attitudes*) captures respondents' perceptions of the potential benefits their firm could gain from implementing DT. It is measured by an additive index based on responses to items addressing the benefits of each of the five phases of the Design Sprint.

The third dimension (3. *Intentions*) is assessed through two indices, reflecting respondents' desire and expectations regarding their firm's investments and adoption of design methods in the next 6–12 months. The first set of questions asks respondents the extent to which they would like their firm to undertake certain actions, while the second asks whether they believe their firm will actually undertake these actions.



**Fig. 2.** Sectoral distribution of firms in the sample.

**Table 2**  
Outcome variables description.

Dimension	Measure description	Question				Index		Cronbach's $\alpha$	
		BS	FUS	N° Items	Type	Method	Metric	BS	FUS
<i>1) Knowledge</i>									
1.1 General Design Knowledge	Respondent's self-perception measure of their general knowledge on i) User-Centered Design, ii) Design Thinking and iii) Design Sprint	Q9	Q5	6	Likert scale	Principal Component Analysis	Normalized score, 0-10	0.905	0.906
1.2 Design Sprint Knowledge	Respondent's actual methodological knowledge of the Design Sprint	n.a.	Q7-Q11	5	Quiz	Summative index	Normalized score, 0-10	n.a.	n.a.
1.3 Knowledge to implement Design Sprint	Respondent's self-perception of their ability to carry out a Design Sprint	Q10	Q6	5	Likert scale	Principal Component Analysis	Normalized score, 0-10	0.824	0.876
<i>2) Attitudes</i>									
2.1 Attitude towards Design Thinking	Respondent's self-perception of the benefits that the company may gain in implementing Design Thinking	Q12	Q13	5	Score	Weighted summative index	Normalized score, 0-10	0.688	0.761
<i>3) Intentions</i>									
3.1. Desire for adoption of design methods by the company	Respondent's desire for adoption of design methods in his/her company	Q13	Q14	7	Likert scale	Principal Component Analysis	Normalized score, 0-10	0.774	0.791
3.2. Expectation of adoption of design methods by the company	Respondent's expectation of adoption of design methods in his/her company	Q14	Q15	7	Likert scale	Principal Component Analysis	Normalized score, 0-10	0.838	0.809

**Notes:** Dimensions 1.1 to 2.1 were measured by means of an N-item questionnaire developed by the researchers. Dimensions 1.2 to 2.1 were asked at each phase of the Sprint. Dimensions 3.1 and 3.2 were asked by listing possible actions to be performed by the Company in the next 6–12 months.

Both sets of questions are Likert-scale items, analyzed via principal component analysis.

The FUS questionnaire also explored potential barriers to implementing design methods from the Contest. Internal factors, such as prior investments, risk aversion, organizational rigidities, lack of skilled labor, and insufficient knowledge of design methodologies, were considered. External factors, including market conditions and customer unresponsiveness, were also assessed. Barriers to innovation are common in innovation surveys, and we adapted a battery of questions from the Community Innovation Survey (CIS-Eurostat) to fit our context.

**4.4. Randomization, survey participation and attrition**

After completing the baseline survey (BS), firms were randomly assigned to either a treatment group (N = 60) or a control group (N = 130) using a stratified randomization design based on country and the level of design experience of the candidates. Pre-treatment design experience was selected as a variable predicting outcomes. Stratified randomization was carried out within each country after the recruitment period ended and the list of candidates was confirmed. The outcome of the randomization was communicated to the firms. **Table 3** presents the differences between the treatment and control groups based on observable characteristics and survey responses. Overall, the baseline characteristics of the two groups are equivalent, as evidenced by t-tests showing no statistically significant differences between the groups for the observed baseline characteristics of firms and respondents. Although not statistically significant, there are some notable differences: control firms are more concentrated in the ICT sector (31.5 % versus 25 % in the treatment group), and control group participants tend to be younger with a higher proportion of Masters-level graduates (61 % versus 55 %). The two knowledge indicators show more variation between the groups, but overall, the baseline characteristics confirm the groups' equivalence.

Three weeks after the Contest, all firms were invited to complete a Follow-Up Survey (FUS). The FUS was collected between April and May 2021, with a response rate of 73.2 %, but with notable differences between the two groups: 95 % of the treatment group responded, compared to 63.1 % of the control group. Despite following the same protocol for timing, invitation messages, and reminders, the final differential attrition was 31.9 percentage points, with some between-

**Table 3**  
Equivalence balance test.

	Controls (mean)	Treated (mean)	T-test (p-value)	Std. difference <sup>a</sup>
<i>Pre-intervention outcomes</i>				
1.1 General Design Knowledge	6.241	6.511	0.457	0.116
1.3 Knowledge to implement Design Sprint	6.372	6.605	0.464	0.114
2.1 Attitudes towards Design Thinking	5.479	5.502	0.955	0.001
3.1 Desire for adoption of design methods <sup>b</sup>	6.572	6.717	0.695	0.061
3.2 Expectation of adoption of design methods <sup>b</sup>	5.620	5.781	0.630	0.075
<i>Company characteristics</i>				
Company ICT sector (%)	0.315	0.250	0.361	-0.142
N. of employees	19.054	20.583	0.777	0.044
Company has research collaboration (%)	0.485	0.500	0.845	0.030
Company has a designer (%)	0.815	0.833	0.766	0.046
H.E. graduates (%)	79.426	79.875	0.920	0.016
<i>Respondent characteristics</i>				
Design experience (0–7)	4.531	4.600	0.784	0.043
Older than 40 yrs old (%)	0.369	0.483	0.138	0.231
Has a master's degree (%)	0.615	0.550	0.396	-0.132
Suitability score (5-25)	19.469	19.633	0.737	0.052
N	130	60	190	190

<sup>a</sup> (Standardized effect size).

<sup>b</sup> by the Company in the next 6–12 months.

country heterogeneity. To assess whether this differential attrition introduces bias in the comparison between treatment and control groups, several checks were performed and are detailed in the appendix. These tests aim to determine: i) whether the attrition difference is linked to firms' or respondents' characteristics or pre-treatment outcomes (LPM on the probability of responding to the FUS, **table A.1**); ii) whether those who responded to the FUS are similar to those who did not (t-tests on the

control group subsample, table A.2); iii) whether statistically significant differences exist between the treatment and control groups among FUS respondents (equivalence test, table A.3); and iv) a joint test of significance for the equivalence test in iii) (table A.4). All tests in the appendix suggest that no firm or participant-related characteristics are associated with the probability of responding to the survey, indicating no systematic differences between those who did and did not respond to the FUS in the control group.

4.5. Estimation approach

The impact of the Contest is assessed based on the outcome variables described earlier. Specifically, the impact estimates are ‘intent-to-treat’ (ITT) estimates, as the analysis focuses on “assignment to the treatment” rather than “receipt of the treatment.” To address potential bias caused by differential attrition and account for the randomization strata, we estimated regression-adjusted ITT. Three primary model specifications were used: i) a linear regression model (OLS) with stratification variables, which accommodates the stratification design and different allocation ratios; ii) an OLS model that includes the pre-treatment measure of the outcome (where available, excluding the quiz-based outcome) to improve statistical precision and adjust for potential imbalances; and iii) an OLS model that includes the product/challenge suitability score and a dummy variable indicating whether the firm operates in the ICT sector, as these variables were weakly imbalanced or linked to FUS non-response. This model also includes a dummy to identify whether FUS respondents were the same individuals as BS respondents (93 % were the same person). Due to the limited sample size and large differential attrition, we present the estimates based on the third specification.

5. Results

Table 4 shows the effects of participating in the Contest on the three dimensions investigated in this paper: knowledge, attitudes, and intentions. As both the knowledge and intention dimensions comprise multiple sub-dimensions (three for knowledge and two for intentions), coefficients are estimated for each sub-dimension.

For each dimension, we report the control mean, effect size with corresponding confidence intervals (C.I.), standardized effect size with its C.I., and the sample size. Model specification iii), the most restrictive model outlined in Section 4, serves as the benchmark. This model takes into account all factors from stratified randomization, firm and respondent characteristics, and pre-treatment results, allowing us to better address the loss of observations in the control group. The table also includes the control group’s averages. Additionally, the standardized effect size (Std. effect size) of the third model is provided to help interpret the magnitude of the impacts for each outcome.

In general, the results indicate that the intervention had significant effects on increasing 1. Knowledge, particularly 1.2. Design Sprint Knowledge and 1.3. Knowledge to Implement Design Sprint. These effects were large, positive, and statistically significant: +1.1 points (a 19 %

increase) for 1.2. Design Sprint Knowledge, and +0.71 points (a 12 % increase) for 1.3. Knowledge to Implement Design Sprint. The standardized effect size supports the higher magnitude of the former over the latter. Overall, the results show that participating in the Contest significantly enhanced the methodological knowledge of the Design Sprint method within SMEs by nearly one-fifth and increased their self-perceived capability to implement it (e.g., applying it to a real project) by 12 %. Positive but non-significant impacts were observed for 1.1. General Design Knowledge. This could be attributed to firms already operating in the digital space having relatively high general knowledge of these methods. This is confirmed by the fact that the average level of the control group (those who did not participate in the intervention) was already 6.3/10.

When it comes to attitudes and intentions toward implementing design methods, the Contest had non-significant effects. All coefficients related to these dimensions are not significant, and the magnitude of the effects is also very small.

The discrepancy between the positive impacts found on attitudes toward DT and the lack of impact on the two indicators of intentions may be explained by respondents being aware of practical constraints on firms investing more in design approaches. These constraints were already high before the intervention (as seen in Table 2) and seem to persist after the Contest. To further investigate this, we examine the information collected in the FUS data. Table 5 shows the differences

Table 5 Obstacles that firms would face in undertaking design approaches (% of respondents answering “probably”, “very probably” or “definitely”).

Variable	Treated	Control	
1. Prior investments	33.30 %	34.10 %	
2. Market conditions or excessive perceived economic risks	26.30 %	18.30 %	
3. Organizational rigidities within the enterprise	8.80 %	14.60 %	
4. Lack of qualified personnel capable of coordinating and drive such initiatives	8.80 %	23.20 %	**
5. Lack of information on how design methodologies work	5.30 %	18.30 %	**
6. Lack of information on market suppliers (do not know potential service providers)	3.50 %	11.00 %	*
7. Insufficient flexibility of regulation or standards	1.80 %	6.10 %	
8. Lack of customer responsiveness to new goods or services	19.30 %	8.50 %	
9. Lack of trustworthy evidence about the benefits of these methodologies (e.g. ROI – Return on Investment)	17.50 %	14.60 %	
10. Lack of awareness of benefits of these methodologies	12.30 %	13.40 %	
11. We fear that adopting these methodologies will disrupt our current product development practices	5.30 %	11.00 %	
12. We do not cover the entire manufacturing process (the interaction design is done by our suppliers or clients)	3.50 %	12.20 %	
Statistical significance: *p < 0.10, **p < 0.05, ***p < 0.01			

Table 4 Effects of the contest (OLS).

	Control mean	ITT	C.I.	Std. effect size	C.I effect size	Controls	N
<b>1. Knowledge</b>							
1.1 General Design Knowledge	6.3	0.361	[-0.289,1.012]	0.170	[-0.136,0.476]	Y	139
1.2 Design Sprint Knowledge	5.9	1.096***	[0.294,1.898]	0.435***	[0.117,0.754]	Y	139
1.3 Knowledge to implement Design Sprint	5.9	0.711**	[0.026,1.397]	0.337**	[0.012,0.662]	Y	139
<b>2. Attitudes</b>							
2.1 Attitude towards Design Thinking	5.0	0.447	[-0.382,1.277]	0.180	[-0.154,0.513]	Y	139
<b>3. Planned actions</b>							
3.1 Desire for adoption of design methods <sup>†</sup>	6.0	-0.179	[-0.964,0.605]	-0.078	[-0.417,0.262]	Y	139
3.2 Expectation of adoption of design methods <sup>†</sup>	4.9	-0.096	[-0.749,0.556]	-0.044	[-0.346,0.257]	Y	139

95 % confidence intervals in brackets. \*p < 0.10, \*\*p < 0.05, \*\*\*p < 0.01.

<sup>†</sup>by the Company in the next 6–12 months.

between the treatment and control groups regarding the obstacles and constraints that firms face in adopting design approaches, as reported by participants. It represents the share of respondents who indicated that each obstacle was probable, very probable, or definitely an issue.

It is worth noting that the intervention was effective in reducing the perception of obstacles in implementing design approaches, such as the lack of qualified personnel and insufficient information on design methods, which were key objectives of the intervention. However, the discrepancy between the knowledge gained and the attitudes and willingness to implement these methods, as seen in Tables 4 and is reflected in several dimensions, including risk aversion, organizational rigidities, customer responsiveness, and the belief that these methods can lead to tangible benefits at the company level.

This discrepancy may be attributed to the size of small firms (as shown in Table 1): being generally smaller, they are more risk-averse, less open to product changes, and more dependent on customer structure. As a result, they may be less convinced that adopting these practices will significantly impact their daily business.

## 6. Discussion and conclusion

This study examined the impact of a Design Sprint-based innovation contest on SMEs' adoption of design approaches. The results suggest that the intervention was effective at improving participants' design knowledge, particularly in the methodology and practical application of the Design Sprint. Participants showed a 19 % increase in Design Sprint Knowledge and a 12 % increase in Knowledge to Implement Design Sprint, compared to the control group. However, the intervention did not lead to significant changes in attitudes or intentions to adopt design methods. While the Contest effectively reduced perceived barriers such as lack of qualified personnel and insufficient information on design methods, it did not address deeper organizational challenges like risk aversion, corporate rigidities, and concerns about customer responsiveness.

Our findings suggest that while innovation contests can effectively transfer explicit design knowledge, they may not be sufficient for driving organizational change, particularly in SMEs with limited investment capacity. The increase in design knowledge aligns with previous research suggesting that hackathons and similar events can promote learning, at least at an introductory level (Flus and Hurst, 2021). However, the lack of significant changes in attitudes and intentions indicates that further research is needed to understand how knowledge transfer translates into actual organizational change.

Several factors likely contributed to these results. The short duration of the Contest (three days) may have been too brief to build the necessary practical knowledge for participants to apply design methods independently. Additionally, the use of students as "challenge solvers" may have diminished the perceived value of design among SME representatives, who may prioritize professional experience and tangible results. As design is often seen as an "experience good" (Acklin, 2013), its value is typically recognized after concrete results are demonstrated, something that may not have been fully achieved in the Contest.

SMEs' limited absorptive capacity may have also played a role in the outcomes. Previous research shows that firms with low capacity to absorb external knowledge often struggle with knowledge transfer (Franzò et al., 2023). In this study, SMEs might have faced challenges in recognizing the value of design and linking it to their business processes (Zahra and George, 2002). This suggests that more immersive exposure to design thinking may be necessary to bridge the gap between knowledge acquisition and implementation.

Leadership characteristics within SMEs may have further influenced the effectiveness of the intervention. According to Ahn et al. (2017), leadership traits such as openness to collaboration, entrepreneurial orientation, and prior experience can shape how external knowledge is absorbed and applied. Furthermore, SMEs tend to adopt OI practices on a project basis rather than as a broader strategic orientation (Barrett

et al., 2021). This could explain why participants learned design methods for specific projects but did not intend to apply them strategically across the organization.

The findings have important implications both theoretically and practically. From a theoretical perspective, the study contributes rigorous empirical evidence on the effectiveness of innovation contests targeting SMEs. It addresses a gap in DT research, moving beyond anecdotal evidence and bridging the gap between DT and OI frameworks. Practically, the results suggest that innovation contests can serve as cost-effective platforms for SMEs to access external knowledge, especially in design-related domains. However, they also highlight the need for complementary, long-term support mechanisms to facilitate the sustained adoption of design practices.

There are several limitations to consider when interpreting these results. First, the generalizability of the findings is limited by the pre-selection of SMEs already inclined toward innovation, which may not represent less innovation-focused firms. Second, the study did not include follow-up measurements to assess whether knowledge gains were sustained or whether attitudes and intentions changed over time. The absence of qualitative data further limits the study's contextual richness, as interviews or case studies could have provided more insight into why attitudes remained unchanged despite knowledge gains. Lastly, participants' awareness of being part of an experiment may have influenced their behavior, although the use of an objective outcome measure, the knowledge quiz, helps mitigate this potential bias.

Future research could explore several promising directions. First, extending the intervention duration might yield more substantial results, while a larger sample size would increase the generalizability of the findings. Longitudinal studies could examine the longer-term effects of innovation contests, such as their impact on networking or clustering among participating firms. Tracking whether participants integrate DT into product development or successfully commercialize prototypes developed during the Contest would provide valuable insights. Finally, natural field experiments could offer further understanding of how design approaches are adopted and implemented in SMEs.

In conclusion, while the Design Sprint-based innovation contest successfully increased design-related knowledge among SME participants, it did not lead to significant changes in attitudes or intentions toward adopting design methods. This suggests that while innovation contests can help SMEs acquire new skills, additional long-term support may be necessary to facilitate organizational change.

## CRedit authorship contribution statement

**Davide Azzolini:** Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Supervision, Project administration. **Nicola Doppio:** Conceptualization, Validation, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition. **Sascha Kraus:** Validation, Writing – original draft, Writing – review & editing. **Luca Mion:** Conceptualization, Resources, Supervision, Funding acquisition. **Iunio Quarto Russo:** Validation, Writing – original draft, Writing – review & editing, Visualization. **Alessio Tomelleri:** Methodology, Validation, Formal analysis, Writing – original draft, Writing – review & editing, Visualization.

## Statements and declarations

An ethics approval was not necessary for the study according to European Union and EU national laws in force at the time when the research was conducted. Personal data from individuals participating in the project were collected and treated according to General Data Protection Regulation (GDPR) compliant data treatment policies.

## Declaration of competing interest

The authors declare no relevant financial or non-financial competing interests to report.

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supporting the adoption of user-centered product design in SME. More information about the project can be found at <https://www.200smechallenge.eu>. This article provides the complete set of results and robustness tests as well as a more thorough discussion for an academic audience. We would like to thank all partners involved in the 200SMEchallenge project for allowing the experiment to take place. Without their work and the work of the people involved in the 200SMEchallenge project, this paper could not have been written. All remaining errors are ours. We also thank the European Commission for funding the 200SMEchallenge project (<https://cordis.europa.eu/project/id/824212>), the European Innovation Council, and the SMEs Executive Agency (EISMEA) for the support provided to us during its implementation.

## Appendix

### A.1 Questionnaire items

Dimension	#	Question
<i>1. Knowledge</i>		
1.1 General Design Knowledge ( <i>Likert Scale</i> )	Q5	Please, express the extent to which you agree/disagree with the following statements: 1. I know what "User Centered Design" is 2. I would feel confident to explain to my colleagues what "User Centered Design" is 3. I know what "Design Thinking" is 4. I would feel confident to explain to my colleagues what "Design Thinking" is in practice 5. I know what a "Design Sprint" is 6. I would feel confident to explain to my colleagues what a "Design Sprint" is in practice
1.2 Knowledge to implement Design Sprint ( <i>Likert Scale</i> )	Q6	Please, express the extent to which you agree/disagree with the following statements: 1. I am able to define a design problem in such a way that it is easily comprehensible by people outside our company (consultants, suppliers, partners) 2. I am able to effectively manage creative ideation processes 3. I am able to take up decisions on the best design solution to implement starting from a large variety of ideas 4. I am able to pursue rapid and cheap prototyping of a design solutions (e.g. wireframing, mockups, interactive prototypes) in order to test it with users 5. I am able to set up and execute reliable user testing (the right profile and number of users) to validate those ideas/solutions
1.3 Design Sprint Knowledge ( <i>Quiz</i> )	Q7 Q8 Q9 Q10 Q11	In the Design Sprint, how should the company frame the Design problem? How is the ideation phase done in the Design Sprint? How are ideas of solutions expressed and shared in the Design Sprint? What is a prototype in the Design Sprint? What is the main purpose of involving users and customers in the Design Sprint?
<i>2. Attitudes</i>		
2.1 Attitudes towards Design Thinking ( <i>Score</i> )	Q12 Q13	How would you rank the importance of the following aspects when pursuing innovation of products or processes in your company? 1. Having a leadership with a strong vision 2. Incorporating the state-of-the-art technology 3. Creating strategic partnerships with key players 4. Using design thinking and user-centered design 5. Optimizing processes, organization and operations 6. Focusing on finance How much do you think each of these aspects of design thinking could benefit your company? 1. Defining a design problem in such a way that it is easily addressable by others (consultants, suppliers, partners, customers, users) 2. Effectively managing creative processes to ideate solutions to design problems 3. Taking up decisions on the most appropriate design solutions to implement, starting from a large variety of ideas 4. Pursuing rapid and cheap prototyping of a design solutions (wireframing, mockups, interactive interfaces) in order to test it as soon as possible with users 5. Setting up and execute reliable user testing (the right profile and number of users) to validate those design ideas/solutions
<i>3. Planned actions</i>		
3.1 Desired design methods adoption by the company in the next 6–12 months ( <i>Likert Scale</i> )	Q14	Thinking about the next 6–12 months, would you like that your company undertake any of the listed actions? 1. Collect feedback from users or customers with regards of your existing products in order to improve their value 2. Involve users or customers to test ideas and prototypes of new products and services (or new functionalities of existing products) 3. Hire new staff trained/experienced in design (e.g., User Experience Designer; Interaction Designer; Information Architect; User Interface Designer; Service Designer) 4. Increase the time dedicated to the design phases of new projects 5. Increase the budget dedicated to design phases of new projects 6. Hire an external User Experience design agency or freelancer to improve our capability of designing better digital products

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(continued)

Dimension	#	Question
3.2 Expected design methods adoption by the company in the next 6–12 months ( <i>Likert Scale</i> )	Q15	7. Invest in user-centered design training for its employees
		To what degree do you think that in the next 6–12 months your company will actually undertake any of the actions listed below?
		1. Collect feedback from users or customers with regards of your existing products in order to improve their value
		2. Involve users or customers to test ideas and prototypes of new products and services (or new functionalities of existing products)
		3. Hire new staff trained/experienced in design (e.g., User Experience Designer; Interaction Designer; Information Architect; User Interface Designer; Service Designer)
		4. Increase the time dedicated to the design phases of new projects
		5. Increase the budget dedicated to design phases of new projects
		6. Hire an external User Experience design agency or freelancer to improve our capability of designing better digital products
		7. Invest in user-centered design training for its employees

A.2 Additional checks

In order to check if, based on the observed baseline characteristics, this differential attrition introduces bias in the comparison of the treatment and the control groups, a number of checks have been performed.

Table A.1 tests if the treated-control difference in attrition is accounted for by firms’ and applicants’ characteristics or pre-treatment outcomes. As shown in the table, no covariate is found to be statistically associated with the probability of not responding to the FUS. The only statistically significant coefficient is the one relative to the treatment status: this means that treated firms were more likely to respond to the follow-up, but no other firm or applicant characteristics predict the probability of answering the FUS.

**Table A.1**  
LPM on the probability of responding to the FUS

	Coefficient [95 % Conf. Interval]
<b>Treated</b>	<b>-0.316*** [-0.443,-0.188]</b>
Company ICT sector (%)	-0.034 [-0.176,0.108]
N. of employees	-0.001 [-0.003,0.001]
Company has research collaboration (%)	-0.084 [-0.215,0.046]
HE graduates (%)	-0.001 [-0.003,0.001]
Design experience (0–7)	0.006 [-0.068,0.080]
Older than 40 years old	-0.012 [-0.068,0.080]
Has a master’s degree	0.020 [-0.114,0.153]
Suitability score (5-25)	-0.001 [-0.023,0.021]
General Design Knowledge	0.008 [-0.024,0.040]
Knowledge to implement Design Sprint	-0.022 [-0.057,0.012]
Attitudes towards Design Thinking	0.010 [-0.019,0.038]
Desired design methods adoption	0.025 [-0.009,0.058]

Table A.2 shows the results of a series of t-tests run only on the sub-sample of the control group to check if those answering the FUS are, on average, equivalent to those not answering it. This analysis suggests again that no firm or participant characteristics are associated with the probability of answering the survey. In other words, there is no indication that the control group subjects who refused to take part in the follow-up survey were systematically different from those who decided to participate.

**Table A.2**  
T-test equivalence test of control units non-responding vs. responding to the FUS

	(1) No answer (mean)	(2) Answer (mean)	(3) T-test (p-value)
<i>Pre-intervention outcomes</i>			
General Design Knowledge	6.411	6.142	0.508
Knowledge to implement Design Sprint	6.246	6.447	0.584
Attitudes towards Design Thinking	5.785	5.301	0.307
Desired design methods adoption	6.964	6.342	0.167
Expected design methods adoption	5.869	5.474	0.336
<i>Company characteristics</i>			
Company ICT sector (%)	0.333	0.305	0.739
N. of employees	16.042	20.817	0.457
Company has research collaboration (%)	0.417	0.524	0.239
Company has a designer (%)	0.833	0.805	0.689
HE graduates (%)	77.558	80.519	0.576
<i>Respondent characteristics</i>			
Design experience (0–7)	4.417	4.598	0.546
Older than 40 years old (%)	0.333	0.390	0.520
Has a master’s degree (%)	0.667	0.585	0.362
Suitability score (5-25)	19.906	19.213	0.211
N	48	82	130

Table A.3 then replicates the same group equivalence tests shown in Table A.2 but conditioning only on the “analytical” sample, i.e., the sample of those who filled in the FUS (N = 139). The goal of this analysis is to check if the group equivalence established at baseline also holds after losing many subjects in the control group at follow-up, and again, there is no indication that those control group subjects refusing to take part in the follow-up survey are systematically different from those who decided to participate.

**Table A.3**  
Group equivalence re-tested on the sub-sample of FUS respondents

	(1)	(2)	(3)	(4)
	Controls (mean)	Treated (mean)	T-test (p-value)	Difference (Standardized effect size)
<i>Pre-intervention outcomes</i>				
General Design Knowledge	6.142	6.455	0.447	0.131
Knowledge to implement Design Sprint	6.447	6.586	0.684	0.070
Attitudes towards Design Thinking	5.301	5.412	0.805	0.043
Desired design methods adoption	6.342	6.655	0.434	0.135
Expected design methods adoption	5.474	5.760	0.421	0.139
<i>Company characteristics</i>				
Company ICT sector (%)	0.305	0.246	0.448	-0.131
N. of employees	20.817	21.526	0.912	0.019
Company has research collaboration (%)	0.524	0.491	0.703	-0.065
Company has a designer (%)	0.805	0.825	0.772	0.050
HE graduates	80.519	79.255	0.786	-0.065
<i>Respondent characteristics</i>				
Design experience (0-7)	4.598	4.614	0.952	0.010
Older than 40 years old (%)	0.390	0.474	0.331	0.168
Has a master's degree (%)	0.585	0.561	0.781	-0.048
Suitability score	19.213	19.789	0.286	0.184
N	82	57	139	

Table A.4 shows the results of a joint test of significance. Based on this test, the suitability score is the only variable found to be slightly statistically associated with the treatment group status. This variable was not imbalanced in the starting sample (Table 3).

**Table A.4**  
F-test of group balance among FUS respondents

Variables	Coefficient [95 % Conf. Interval]
General Design Knowledge	0.014 [-0.032,0.061]
Knowledge to implement Design Sprint	-0.005 [-0.060,0.050]
Attitudes towards Design Thinking	-0.003 [-0.046,0.040]
Desired design methods adoption	0.005 [-0.051,0.060]
Expected design methods adoption	0.014 [-0.044,0.073]
Company ICT sector (%)	-0.091 [-0.315,0.133]
N. of employees	-0.001 [-0.004,0.002]
Company has research collaboration (%)	-0.087 [-0.291,0.118]
HE graduates (%)	-0.001 [-0.005,0.003]
Design experience (0-7)	0.060 [-0.056,0.175]
Older than 40 years old	0.036 [-0.177,0.248]
Has a master's degree	-0.072 [-0.281,0.137]
Suitability score (5-25)	<b>0.034* [-0.003,0.071]</b>
Constant	-0.464

### A.3 Participants' satisfaction with the Contest

Participants in the treated group were asked additional questions in the FUS to assess their satisfaction with the Contest. They were asked to express their agreement/disagreement on seven statements related to the solutions: the optimization of the existing product, the incremental product innovation (e.g., new functionalities), the featured radical product innovation (novel added value or new meanings), the alignment with the initial problem statement, the maturity and exploitability of the resources, an increase of the product experience, and the improvement of the product based on the results of the Contest.

After a principal component analysis from the item in the question, we computed a normalized 0–10 index (left panel) and compared it with the rate, on a 0–10 scale, given to the Contest by the participants (right panel).

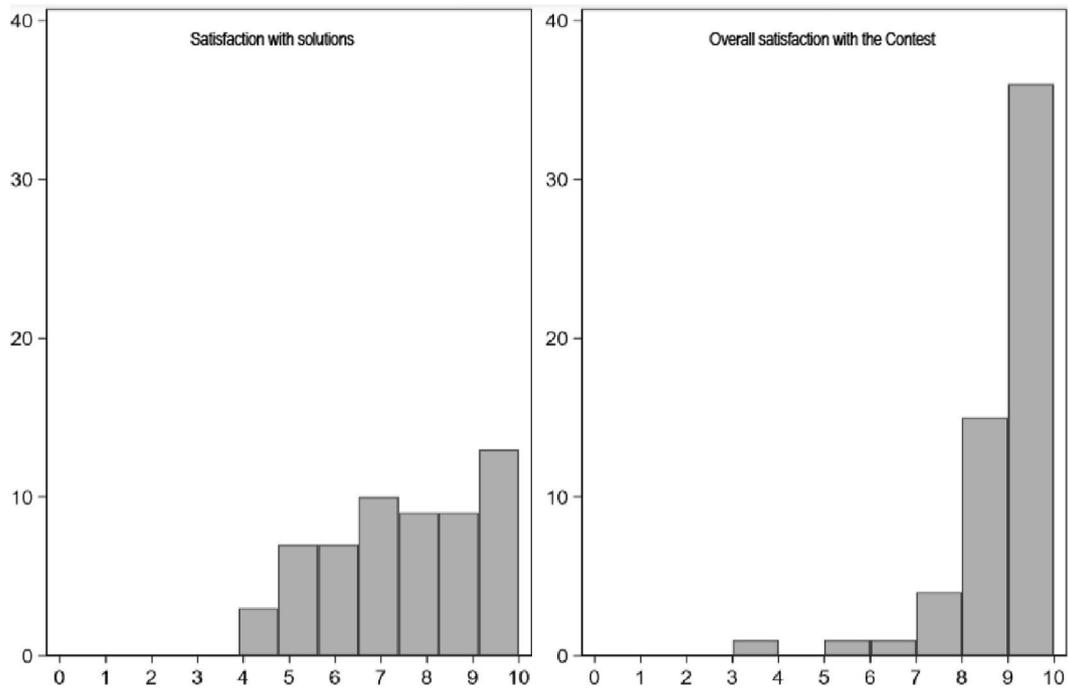


Fig. A.1. Participants' satisfaction with the Contest.

Although the formats of the two questions are not identical, and hence the two indices are not directly comparable, these findings seem to suggest that the satisfaction of companies with the initiative as a whole may have only partially been due to the relevance of its outputs (prototypes, designs, mockups, user insights), and can therefore be related to other aspects such as increase of knowledge and awareness about the core methodologies, but also networking opportunities, talent scouting, and other benefits usually mentioned by companies participating in the Contest.

A.4 Willingness to apply to the next edition of the Contest

Figure A.2 depicts the distribution of the treated companies with respect to the possibility of participating in another contest if there was one (question Q19, item 5 in the FUS).

The figure shows that the majority of the companies covered are in favor of repeating the Contest experience.

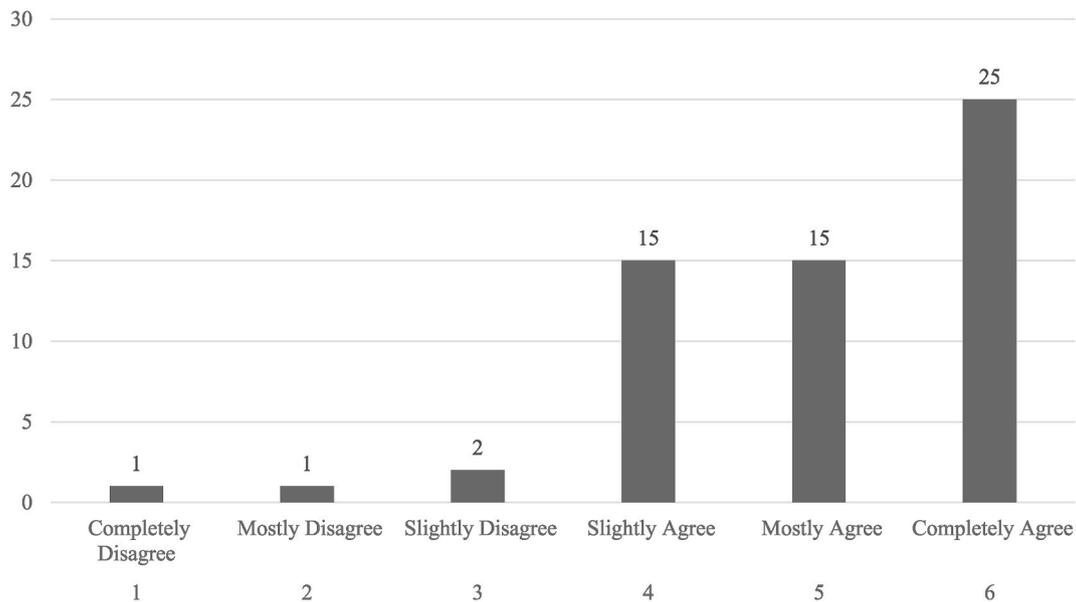


Fig. A.2. Participants' willingness to apply to the next edition of the Contest

## Data availability

The authors do not have permission to share data.

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