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Research on the Effect of Design Thinking on Enterprise Sustainable Innovation Ability and Team Performance

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Abstract: Design thinking is an interdisciplinary problem-solving approach that combines user-centered focus, challenge framing, visual thinking, experimental methods, and cross-functional collaboration. It has always been regarded as an important means to improve corporate sustainable innovation capabilities and team performance. However, its effectiveness is a controversial topic, with some proponents praising its ability to solve systemic problems while others question its applicability within traditional business processes and its impact on sustainable innovation success. Because of its exploratory nature, there is currently a lack of quantitative empirical research on its impact. Therefore, this study takes Huawei's electric vehicle R&D sustainable innovation project as an example to explore the impact of design thinking on corporate sustainable innovation capabilities and team performance by analyzing the relationship between design thinking and team empowerment. The study included hypotheses, semi-structured qualitative interviews, quantitative questionnaire data, and structured equation model analysis. This study reveals the mechanism by which design thinking operates in industrial enterprises. There is a positive correlation between design thinking practice and team performance in sustainable innovation projects. Moreover, through the regulation of design thinking, team performance can be strengthened. However, the applicability of design thinking in highly sustainable innovation environments needs further research. In summary, this study provides fundamental insights into the complex relationships between design thinking, corporate sustainable innovation, and team performance, and provides direction for future research.

Keywords: design thinking; sustainable innovation capabilities; team performance; team empowerment; user-centricity



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1. Introduction

Although the principles and theories of design thinking were previously mainly discussed in the fields of industrial design or design science, with more and more enterprises adopting people-oriented innovative methods, design thinking has been introduced by many enterprises into solving related enterprise problems. Design thinking is defined as the thinking and inspiration generated by problem-solving in design, which often goes beyond traditional design methods [1].

Despite the existence of similar concepts, the conceptual discussion of design thinking remains relatively new. Some argue that design thinking is an operational mode that anyone can easily adopt, capable of fundamentally transforming entire companies and providing a balanced approach to exploration and exploitation in the early stages of sustainable innovation. However, recent research suggests that introducing design thinking can pose challenges, especially in industries that have previously employed different approaches [2].

Therefore, there is a need for a clearer conceptualization of design thinking to study its impact on key internal and external outcomes, such as team empowerment and sustainable innovation performance. To better understand design thinking, this study defines it as a set of practices that include user-centeredness, problem framing, visualization, experimentation, and diversity [3]. These practices are considered central to design thinking and can be used to measure the degree of design thinking practices within sustainable innovation projects. This definition helps bridge design thinking with existing sustainable innovation research [4].

In addition, in numerous empirical studies, team empowerment has been demonstrated as a crucial factor for sustainable innovation and team performance [4]. There are multiple review articles on empowerment [5], typically distinguishing between structural empowerment and psychological empowerment, as well as empowerment at individual, team, and organizational levels [5]. Structural empowerment encompasses the process of shifting responsibility and authority from upper management to employees and can be an important antecedent to psychological empowerment, which describes the sense of control over one's work [6]. At the team level, empowerment is conceptualized across four dimensions: Efficacy, referring to the belief that the team can work effectively; Meaning, indicating the perception that the team's work is valuable and meaningful; Autonomy, reflecting the team's independent control over its work; and Impact, signifying the perception that the team's work is crucial for the organization and clients [6]. Empowerment is a dynamic motivational construct that describes a state of striving [7]. This study mainly uses team empowerment for research. In this study, team empowerment is understood as a conceptualization based on Kirkman et al.'s [8] team-level psychological empowerment [9].

Therefore, this article mainly focuses on using sustainable innovation projects as empirical research cases and using questionnaire surveys and structured equation analysis as methods to study the relationships and impact between design thinking, team performance, and sustainable innovation capability. This article is divided into four parts: Firstly, based on relevant hypotheses in the literature, the relationships between design thinking practice, enterprise sustainable innovation ability, team performance, and team empowerment were assumed. Meanwhile, using team authorization as a mediator, the relationship between design thinking practice and team performance was assumed. Secondly, this research selected enterprise sustainable innovation projects (electric vehicle research and development projects under Huawei), set up questionnaires, and conducted questionnaire surveys. Thirdly, empirical quantitative methods using structured equations were used to analyze questionnaire data. Finally, the effect of using design thinking on the relationship between enterprise sustainable innovation capability and team performance was quantitatively evaluated, and the hypothesis was validated.

2. Research Hypotheses

It is very difficult to directly study the relationships between design thinking, enterprise sustainable innovation ability, and team performance. Therefore, this article chooses to use a hypothetical logical strategy [10], which assumes its relationship based on discussions in the relevant literature. The hypothesis provides the basis for the researcher's confirmatory analysis in this article. Firstly, this article constructs a hypothetical conceptual framework, as shown in Figure 1. In this framework, design thinking practices in sustainable innovation projects are seen as a higher-order structure composed of five first-order factors: user attention, problem framework, visualization, experience, and diversity [10]. Secondly, referring to the framework, this article proposes three hypotheses, the first of

which is that the practice of design thinking in sustainable innovation projects has a positive impact on team performance (Hypothesis 1). By linking these practices with existing research, Hypothesis 2 proposes that team authorization can regulate the relationship between design thinking practice and team performance in sustainable innovation projects. Furthermore, from the perspective of contingency, it is assumed that the relationship between design thinking practice and team empowerment is positively moderated by the degree of sustainable innovation in the project (Hypothesis 3). Next, we will introduce each situation one by one in conjunction with Figure 1.

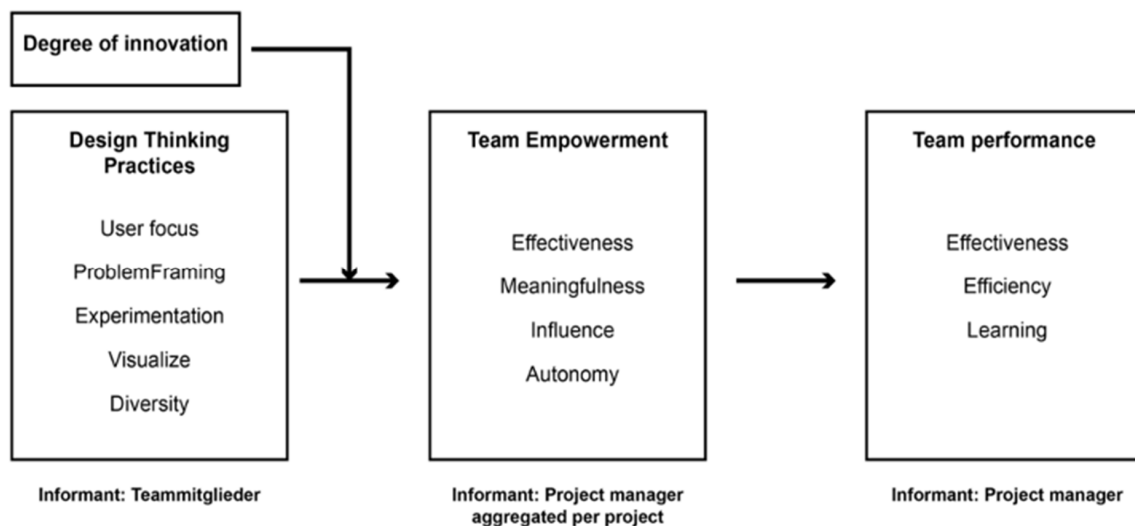


Figure 1. Model for the relationships between design thinking practices, team empowerment, degree of sustainable innovation, and team performance.

2.1. Hypothesis 1: The Practice of Design Thinking in Sustainable Innovation Projects Has a Positive Impact on Team Performance

Although many case studies describe design thinking as a favorable factor in promoting sustainable innovation [11], it is still unclear whether its application will lead to a higher success rate for sustainable innovation. Due to the challenge of directly measuring the accuracy of sustainable innovation success, this study first focuses on the relationship between design thinking practice and team performance in sustainable innovation projects [11]. There is research indicating a positive correlation between team performance and sustainable innovation capability [12]. In addition, due to the advocacy of design thinking for finding the right solutions to the right problems, it can be inferred that it has improved the performance of sustainable innovation projects [13]. Furthermore, it can be concluded that design thinking has a positive impact on the sustainable innovation capability of enterprises.

Therefore, Hypothesis 1: Design thinking practices in sustainable innovation projects have a positive impact on team performance.

2.2. Hypothesis 2: Team Empowerment Can Mediate the Relationship between Design Thinking Practices and Team Performance in Sustainable Innovation Projects

Consistent with previous studies [14], team empowerment is defined as increased task motivation [15]; therefore, team empowerment is directly associated with higher team performance. For example, greater autonomy may mean that the team will not wait for permission and will therefore develop their own learning [15]. Higher autonomy may also be associated with greater risk-taking and ownership, which will have a positive impact on effectiveness [16]. By having a higher sense of purpose in work, the team will also demonstrate higher perseverance and motivation [16]. If a team feels that it has significant influence, it can also learn by improving its understanding of tasks and retrospectively

evaluating its past behavior [16]. This may also mean that the team can autonomously improve its workflow and find more sustainable and innovative solutions.

In addition, there may be a relationship between design thinking practice and team performance, and team empowerment is a potential mediator [17]. The relationship between design thinking practice and team performance may stem from the enhanced team empowerment of design thinking practice [17]. Design thinking is often described as a method of “empowerment” [8]. Therefore, we can to some extent understand the relationship between design thinking practice and team performance through team empowerment. And even strengthening design thinking practice as a form of team empowerment has an impact on team performance.

Therefore, we can propose a second hypothesis: team empowerment can regulate the relationship between design thinking practices and team performance in sustainable innovation projects.

2.3. Hypothesis 3: The Relationship between Design Thinking Practices and Team Empowerment Is Positively Moderated by the Degree of Sustainable Innovation of a Project

Combining Hypothesis 1 and Hypothesis 2, this article assumes that in sustainable innovation projects, the relationship between design thinking practices and team empowerment may be influenced by the degree of sustainable innovation in the project [6,7]. Highly sustainable innovation projects are often characterized by uncertainty and complexity, making it necessary for teams to focus on user needs and seek solutions through experimentation and visualization [18]. In such cases, teams adopting design thinking practices are more likely to feel empowered, as they are more confident in addressing complex problems and finding appropriate solutions [13,14]. The degree of sustainable innovation in a project can moderate the relationship between design thinking practices and team empowerment. Therefore, this study proposes the following hypothesis: The relationship between design thinking practices and team empowerment is positively moderated by the degree of sustainable innovation of a project.

3. Materials and Methods

3.1. Data Sources and Questionnaire Settings

This study conducted a survey in the context of an electric vehicle research and development project within a large multinational corporation in China (HUAWEI, Shenzhen, China). The research selected R&D project teams as the unit of analysis, particularly those with a focus on sustainable innovation. These projects are typically composed of teams formed for specific purposes, possessing their own environments and characteristics, and embedded within the larger company’s culture. Therefore, project managers, project team members, and the heads of larger organizational units affiliated with the respective projects were chosen as information providers.

The company is an innovative technology firm founded in 1985, specializing in research and development of smart hardware and electronic products. As of August 2023, it operates in over 100 countries globally, with an annual revenue of approximately RMB 280 billion (Huawei 2023). The company allocates approximately 6% of its revenue to research and development, which is three times the industry average. Its internal and external communications emphasize its strategic positioning as a technological leader and its pursuit of sustainable innovation and new product development. As a typical Chinese sustainable innovation-driven enterprise, its products and services span various fields, including smartphones, the Internet of Things, and artificial intelligence, among others, demonstrating a high level of innovativeness.

The sample base for this study consisted of a list of all ongoing or recently completed sustainable innovation projects provided by the central sustainable innovation department of the company. Based on this list, we selected projects with a focus on sustainable innovation or new product development, forming the sample (electric vehicle research and development project). Based this sample, one questionnaire was designed for this study

(please see the Supplementary Materials for the questionnaire settings), and three directions were set in the questionnaire:

- The first direction targeted project managers to provide information about the extent of design thinking practices in the project, team cohesion, sustainable innovation level, and team performance. It also assessed their understanding of design thinking and their perception of it.
- The second direction was distributed to project team members in an anonymous format to provide information on the degree of team empowerment within the scope of the study.
- The third direction was distributed to the supervisors of each team to understand their strategic and sustainable innovation orientation within the project environment.

Survey responses were matched between each team member and their respective project manager and supervisor. Team member responses at the project level were then analyzed, and a comprehensive summary was conducted.

The questionnaires setting used standardized reference standards widely employed in research on design thinking, team empowerment, and performance. The main reference standards are as follows:

- **Design Thinking Practices:** The degree of adoption of design thinking practices was measured using a reference standard developed by Carlgren et al. [19]. This reference standard comprises five dimensions: assessing the extent of user focus, problem framing, visualization, experimentation, and diversity. Participants were asked to evaluate these dimensions on a 7-point scale based on their experience.
- **Team Empowerment:** The team-level psychological empowerment reference standards developed by Kirkman et al. [7,8] were employed to assess team empowerment. This reference standards include four dimensions, measuring effectiveness, meaning, autonomy, and impact. Participants were asked to evaluate these dimensions on a 7-point scale based on their team's experience.
- **Team Performance:** Team performance was measured as an indicator of project performance, including project completion time, cost control, quality, and sustainable innovation level. Participants assessed these dimensions on a 7-point scale based on their project's actual performance.
- **Sustainable Innovation Level:** The sustainable innovation level was measured as the degree of sustainable innovation in the project, including market sustainable innovation and technological sustainable innovation. Participants were asked to evaluate these dimensions on a 7-point scale based on the actual sustainable innovation level of their project.
- **Control Variables:** In the analysis, we also controlled for several variables that could influence the relationships between design thinking practices, team empowerment, and team performance, such as project size, project type, and the backgrounds of team members.

3.2. Questionnaire Data Collection

Data collection was conducted within the corporation through online surveys. The survey links were sent to participating project managers, project team members, and heads of relevant organizational units. Participants were assured that their responses would be treated confidentially and only used for research analysis purposes. The questionnaire for each team member was associated with the questionnaires of their respective project managers and supervisors, resulting in a sample of 71 project supervisors. The survey was conducted from July to August 2023, resulting in a total of 830 valid responses. The basic information is shown in Table 1.

Table 1. Basic information about the survey sample.

| Position | Numbers | Number of Men | Number of Women |
|------------------------------|---------|---------------|-----------------|
| Project Manager | 95 | 54 | 41 |
| Designer | 289 | 195 | 94 |
| Product Development Engineer | 375 | 236 | 139 |
| Project Supervisor | 71 | 39 | 32 |
| Total | 830 | 288 | 220 |

3.3. Data Analysis

Structural equation modeling was the primary analysis method for the data in this study. Questionnaire data were analyzed to test hypotheses. The process of structural equation modeling analysis was divided into three parts: variable determination, regression analysis, and structural equation modeling analysis.

Structural equation modeling analysis is essential for this study because it can help explain and analyze complex multivariate relationships, validate research hypotheses, and provide a more comprehensive and in-depth understanding and conclusions for research. Specifically, firstly, SEM is suitable for studying the complex structural relationships between multiple variables. In this article, the relationships between design thinking practice (DTP), team empowerment (TE), and team performance (TP) were studied. This complex multivariate relationship requires modeling and analysis through SEM. Secondly, SEM can help measure and analyze latent variables, i.e., variables that are not directly observable but have an impact on the observed variables. For example, in this study, team empowerment (TE) may be an implicit variable, and its impact on design thinking practice (DTP) and team performance (TP) can be explored through SEM. Thirdly, SEM allows for the exploration of direct and indirect relationships between variables through path analysis and validates the research hypotheses proposed in this study. This study validated hypotheses 1 (direct impact of DTP on TP), 2 (indirect impact of DTP on TP mediated by TE), and 3 (the relationship between DTP and TE is moderated by project sustainable innovation level) using SEM. Fourthly, SEM provides some fitting indicators (such as chi square test, RMSEA, CFI, etc.) that can help evaluate whether the model in this study fits the data. By evaluating the fit of the model, researchers can determine whether the SEM model used in this study can effectively interpret the research data. Finally, SEM can help this study comprehensively analyze and explain the relationships between various variables, providing a deeper and more comprehensive understanding for the research, revealing the impact mechanism of design thinking practice (DTP) on team performance (TP) through SEM, and how this impact is moderated by team empowerment (TE) and project sustainable innovation level.

Furthermore, it should be noted that during the SEM analysis of this study, the focus was on discussing the relationships between design thinking, corporate innovation capability, and team performance. And a research design with multiple information providers was adopted, combining evaluations from multiple participants in different positions and the methods of Podsakoff et al. [20–22], which basically reduced possible risks or method biases. Therefore, factors such as method bias are not the main issues of this study and can be omitted from the focus of discussion. Specifically, this study adopted multiple measures in the questionnaire survey to ensure the accuracy of the study and the cooperation of participants. Firstly, we conducted a preliminary study to ensure that information providers could understand and master the questionnaire content. Secondly, we increased the motivation of participants through individual invitations. The anonymity and data security of information providers were also guaranteed. Meanwhile, participants were informed that there were no correct or incorrect answers in the questionnaire and encouraged to answer honestly. In addition, the questionnaire clearly distinguished between independent and dependent variable questions to prevent participants from guessing the relationships between the questions, reducing the likelihood of them intentionally distorting their answers, making the results more in line with social expectations and more consistent.

4. Results

The hypotheses' structural equation modeling analysis results are mainly divided into three parts. Firstly, using exploratory factor analysis (EFA) to validate standardized reference standards, the main variables were identified. Secondly, a regression analysis was conducted, establishing a linear relationship between variables and preliminarily verifying the relationships between design thinking practice, team empowerment, team performance, and sustainable innovation level. Thirdly, structural equation modeling (SEM) analysis was conducted to explore and validate the complex causal relationships and path models between variables. The detailed results are as follows.

4.1. Determination of Structural Equation Modeling Variables

During the variable determination process, in addition to the newly developed measurement scale (Table 2) for design thinking practices, existing literature-based constructs were used. In some cases, question wording was slightly adjusted to better fit the study's context and unit of analysis. All questions in the survey were measured using a Likert 7-point scale (from 1 = strongly disagree to 7 = strongly agree). All scales were validated through principal component analysis (PCA) to ensure that each question loaded clearly onto one factor. Furthermore, Cronbach's Alpha was examined to confirm the reliability of the scales, with the accepted standard being greater than 0.80 [23,24]. At the individual level, confirmatory factor analysis (CFA) was performed to validate the measurement model. Due to the limited sample size, CFA was not conducted for scales obtained from project managers. Descriptive statistics for the scales used are listed in Table 2.

Table 2. Descriptive statistical data.

| Construct | Averages | td.dev. | a | b | c | d | e |
|--|----------|---------|--------|--------|--------|-------|-------|
| a Team performance | 5.51 | 0.84 | / | / | / | / | / |
| b Proximity of team members | 5.17 | 1.43 | 0.090 | / | / | / | / |
| c Strategic sustainable innovation orientation | 4.95 | 1.04 | −0.119 | −0.019 | / | / | / |
| d Degree of sustainable innovation | 2.93 | 1.07 | 0.411 | −0.221 | −0.170 | / | / |
| e Design thinking practices | 4.97 | 1.01 | 0.365 | 0.086 | −0.063 | 0.366 | / |
| f Team empowerment | 5.33 | 0.70 | 0.467 | 0.182 | 0.104 | 0.088 | 0.282 |

Note: Questions were asked using a 7-point Likert scale. Means and standard deviations were calculated from the sample mean of the scale. $p < 0.05$, $n = 71$.

4.1.1. Dependent Variables

Team performance was measured using three criteria based on existing measurements in the literature. Since project managers have the most knowledge of their teams' performance, they were chosen as the information providers. Four items were used to assess team effectiveness, three items for team efficiency, and three items for team learning. These items were based on the work of Hoegl and Gemünden [24]. Example questions included the following: "Can the project be considered successful based on the results?" (effectiveness), "Are you satisfied with the progress of the project from a corporate perspective?" (efficiency), and "Has the project provided useful results for our future work?" (learning). To further validate the measurement model, PCA and CFA analyses were first performed on the team member data with the same questions. PCA analysis indicated that all items loaded clearly on their respective factors with a threshold of 0.30. In the CFA, all factor loadings exceeded 0.77, and the model fit well (RMSEA = 0.078, CFI = 0.974, SRMR = 0.038). Thus, the measurement model was validated, and project manager data were aggregated for second-level performance using simple mean values.

4.1.2. Independent Variables

Through a systematic literature review, it was found that there are limited quantitative measurements for design thinking [25], and no single scale fully covers the concept. Therefore, a new scale was developed to quantify the extent of design thinking applied in R&D projects. First, the scope of this construct was clarified, defining design thinking practices as five practices applied in the early stages of sustainable innovation projects, namely user focus, problem framing, visualization, experimentation, and diversity [26]. Then, key questions for these five practices were identified through a literature review, discussions with practitioners and researchers in the design thinking field, and workshops. The formulation of these questions allowed for a higher degree of practice to manifest as a higher application of design thinking in projects, without explicitly mentioning design thinking. This way, even if design thinking was not explicitly adopted, these questions could still be used to operationalize projects with characteristics of the concept, ranging from low to high levels. Some questions were slightly modified for quality assurance and tested before final scale development and application. Based on the main study results, the scale underwent validity and reliability verification through PCA analysis. Two items with cross-loadings were removed. Since this new operationalization was only surveyed with 71 project managers, a reliable CFA analysis at the project level was not feasible due to insufficient observations. Therefore, PCA analysis results were used. Factors with eigenvalues exceeding 0.89 were accepted because the Scree plot indicated that the fifth factor also had a significant impact on the analysis [26]. The final scale of 15 questions was a second-order construct comprising five dimensions: user focus (three questions), problem framing (three questions), visualization (two questions), experimentation (four questions), and diversity (three questions). Principal component analysis showed high factor loadings of question variables onto their respective factors, all exceeding 0.70, with no cross-loadings above 0.30. Thus, this validated second-order operational tool for design thinking practices was used for subsequent analysis, enabling the assessment of antecedents and consequences of design thinking in real-world research. This approach allows for the independent evaluation of the effectiveness of design thinking, independent of potential inconsistencies in labels, specific methodologies, or personal beliefs and preferences (Table 3).

Table 3. Exploratory factor analysis of the final second-order operationalization of design thinking practices.

| Design Thinking Practices in This Project | a | b | c | d | e |
|---|-------|-------|-------|-------|-------|
| We had diverse professional origins. | −0.23 | 0.07 | 0.09 | −0.11 | 0.87 |
| We sought different perspectives and inspirations. | 0.29 | −0.07 | −0.04 | 0.04 | 0.71 |
| We were very interdisciplinary; mostly technical, design and business disciplines were represented. | 0.01 | 0.00 | −0.05 | 0.15 | 0.78 |
| We questioned existing things and asked, “What if...?” questions. | 0.17 | 0.78 | 0.01 | 0.04 | −0.07 |
| Our focus was not only on the actual problem being investigated, but also on a holistic view of the problem’s environment. | −0.17 | 0.97 | 0.04 | 0.04 | 0.01 |
| We questioned and reformulated the original problem again and again in order to expand both the problem and the solution space. | 0.26 | 0.74 | −0.05 | 0.13 | 0.01 |
| We created prototypes quickly and often to learn. | 0.83 | −0.06 | −0.03 | 0.11 | −0.04 |
| We tested solution approaches quickly and often. | 0.88 | −0.16 | 0.05 | 0.13 | 0.01 |
| We moved back and forth in a highly iterative way between ideation, concept generation, prototyping and testing. | 0.81 | 0.24 | 0.00 | −0.03 | −0.06 |

Table 3. Cont.

| Design Thinking Practices in This Project | a | b | c | d | e |
|---|-------|-------|-------|-------|-------|
| We tried many different options before we found the right solution. | 0.84 | 0.10 | 0.06 | −0.10 | −0.05 |
| We observed customers in their familiar environment. | 0.03 | −0.10 | 0.94 | 0.04 | −0.30 |
| We tried to understand unspoken needs and problems of the users. | 0.01 | 0.05 | 0.88 | −0.08 | 0.13 |
| We explored how different user groups and stakeholders dealt with the established concept. | / | / | / | / | / |
| We focused on the user experience and let this understanding guide us in our work. | 0.04 | 0.14 | 0.77 | 0.07 | −0.08 |
| We made ideas and findings visible and tangible, e.g., through user stories, mock-ups, or prototypes. | / | / | / | / | / |
| We worked out initial rough representations of the product or service as quickly as possible. | 0.02 | 0.09 | −0.11 | 0.90 | 0.04 |
| We tried to increase the user's understanding by confronting him with prototypical solution sketches (e.g., made of cardboard, in the form of user stories, drawings/sketches, etc.). | −0.01 | 0.04 | 0.20 | 0.82 | −0.01 |

Note: PCF analyses were performed using the promax rotation method; questions that were not part of the adjusted operating method were excluded; $n = 71$.

4.1.3. Mediating Variables

To measure team empowerment, a scale from Kirkman et al. [7,8] was used, consisting of four dimensions: efficacy, meaning, autonomy, and impact, each with three questions. As this construct covers the shared perceptions of teams, team members were selected as information providers. The construct was validated using CFA, and the results showed an excellent fit between the model and the data (RMSEA = 0.067, CFI = 0.968, SRMR = 0.040, see Table 4). Values for each team were then aggregated and used for further analysis. Since the means were calculated across a set of information providers, intraclass correlation coefficients (ICC (2)) were computed to simultaneously assess the consistency between information providers. Consistency among information providers for team empowerment was moderate to strong (ICC (2) = 0.62), with between-group variance significantly greater than within-group variance ($F = 2.64$, $p < 0.000$). Therefore, the data allowed for the aggregation of group means, which would be used in subsequent analyses.

Table 4. Confirmatory factor analysis for team empowerment.

| Team Empowerment | Factor Loading | a | CR | AVE |
|---|----------------|------|------|------|
| Efficacy | 0.77 | 0.84 | 0.85 | 0.66 |
| My team had confidence in itself. | 0.76 | | | |
| My team could achieve a lot if they worked hard. | 0.85 | | | |
| My team felt that it could be very productive. | 0.82 | | | |
| Meaningfulness | 0.90 | 0.90 | 0.91 | 0.77 |
| My team was convinced that the project was important. | 0.72 | | | |
| My team felt that their tasks were valuable. | 0.93 | | | |
| My team felt that their work was significant. | 0.96 | | | |
| Autonomy | 0.64 | 0.71 | 0.73 | 0.48 |

Table 4. Cont.

| Team Empowerment | Factor Loading | a | CR | AVE |
|---|----------------|------|------|------|
| My team could choose different ways to complete the tasks. | 0.66 | | | |
| My team decided together how things should be done in the team. | 0.83 | | | |
| My team made their own decisions without any rules from management. | 0.56 | | | |
| Influence | 0.87 | 0.76 | 0.77 | 0.53 |
| My team had a positive impact on the customers of this company. | 0.73 | | | |
| My team carried out tasks that are very important for this company. | 0.80 | | | |
| My team has made a difference in this organization. | 0.63 | | | |

Note: $n = 345$; RMSEA = 0.067, CFI = 0.968, SRMR = 0.040.

4.1.4. Moderating Variables

Given that design thinking may be particularly useful for highly sustainable innovation projects [27–33], it is important to control for effects solely induced by the degree of sustainable innovation in the project and analyze sustainable innovation level as a moderating variable. To measure sustainable innovation level, a construct comprising four dimensions—technological, market, organizational, and environmental—was used [28–30]. Project managers served as information providers. PCA analysis (all eigenvalues > 1) indicated that the conceptual dimensions of technological and market sustainable innovation were subordinate to the same factor, while organizationally and environmentally sustainable innovation level variables clearly loaded onto their respective factors. Therefore, a three-factor model for sustainable innovation level was adopted in all analyses: (1) technological and market sustainable innovation level (six questions, e.g., our product/service is based on new technological principles), (2) organizationally sustainable innovation level (three questions, e.g., significant changes in our company’s structure were required to introduce our new product/service), and (3) environmentally sustainable innovation level (three questions, e.g., significant changes in our company’s structure were required to introduce our new product/service).

4.1.5. Control Variables

To account for factors that may significantly influence team empowerment and have been reported in the literature, preceding factors of team empowerment were controlled for. As shown in the meta-analysis of empowerment by Seibert, Wang, and Courtright [27], effective management practices, social-political support, leadership, and job design may affect team empowerment. Due to the relatively small sample size, it was not possible to control for all influencing factors. Therefore, leadership was used as an illustrative example. Three questions from Anderson and West [28] covering leadership in the context of strategic sustainable innovation around the team were selected. As this is a contextual variable, managers from the surrounding environment of the team, such as project sponsors or management from the larger organization to which the team belongs, were chosen as information providers. Example questions included “Do employees have a clear understanding of the unit’s goals?” Furthermore, to control for the proximity of team members, a scale from Hoegl et al. [25] consisting of three questions was used to consider the effects of team members’ physical proximity. For this construct, project managers were chosen as information providers because they are the ones with the most knowledge of the positions of all team members and their proximity. Example questions included “Most of my team members work nearby, so it is easy to visit them without much effort”.

4.2. Regression Analysis

Firstly, to ensure the comprehensiveness of the structural equation variables, regression analysis needs to be conducted after the variable analysis is completed. This study used hierarchical regression analysis to test the hypotheses in the study. “Model” here refers to regression models, which are different mathematical models constructed by researchers based on different research questions and hypotheses, used to analyze the relationships between variables. The regression model of this study is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon \quad (1)$$

Among them, Y is the dependent variable (such as team performance); X_1, X_2, \dots, X_n are independent variables (such as sustainable innovation level, team member intimacy, design thinking practice, etc.); $\beta_0, \beta_1, \beta_2, \dots, \beta_n$ is the regression coefficient, indicating the degree of influence of the independent variable on the dependent variable; ε is an error term.

For specific calculations, specific data and regression analysis tools are needed for calculation. This study used statistical software SPSS (Mac SPSS 27) for hierarchical regression analysis and obtained model parameter estimates and significance test results, drawing conclusions through model fitting and statistical inference by inputting data from independent and dependent variables.

The regression analysis results are shown in Table 5. Model 1 examined the direct relationships between control variables and team performance, revealing a positive correlation between sustainable innovation level ($b = 0.278, p = 0.004$) and team member proximity ($b = 0.111, p = 0.088$) with team performance, while no significant relationship was found between strategic sustainable innovation leadership and team performance ($b = -0.032, p = 0.714$). Model 2 validated Hypothesis 1, showing a positive correlation between design thinking practices and team performance ($b = 0.206, p = 0.033, \Delta R^2 = 0.054$).

Table 5. Regression results.

| | Team Performance | | Team Empowerment | | Team Performance | |
|---|------------------|---------|------------------|---------|------------------|---------|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
| Proximity of the team members (project manager) | 0.110 | 0.111 | 0.107 | 0.108 | 0.107 | 0.060 |
| | (0.066) | (0.064) | (0.059) | (0.057) | (0.058) | (0.060) |
| | <0.099> | <0.088> | <0.075> | <0.064> | <0.068> | <0.321> |
| Strategic sustainable innovation orientation (supervisor) | -0.032 | -0.032 | 0.090 | 0.090 | 0.088 | -0.075 |
| | (0.089) | (0.087) | (0.080) | (0.077) | (0.078) | (0.080) |
| | <0.719> | <0.714> | <0.265> | <0.248> | <0.266> | <0.357> |
| Degree of sustainable innovation (project manager) | 0.349 | 0.278 | 0.103 | 0.035 | 0.030 | 0.262 |
| | (0.089) | (0.093) | (0.080) | 0.082 | (0.084) | (0.085) |
| | <0.000> | <0.004> | <0.200> | <0.675> | <0.725> | <0.003> |
| Design thinking practices (project manager) | | 0.206 | | 0.199 | 0.210 | 0.112 |
| | | (0.094) | | (0.084) | (0.090) | (0.090) |
| | | <0.033> | | <0.021> | <0.023> | <0.217> |

Table 5. Cont.

| | Team Performance | | Team Empowerment | | Team Performance | |
|--|------------------|---------|------------------|---------|------------------|---------|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
| Design thinking practices and sustainable innovation level (project manager) | | | | | 0.026 | |
| | | | | | (0.076) | |
| | | | | | <0.731> | |
| Team empowerment (team members) | | | | | | 0.472 |
| | | | | | | (0.126) |
| | | | | | | <0.000> |
| Constant | 4.953 | 4.592 | 4.768 | 4.764 | 4.761 | 2.703 |
| | (0.353) | (0.343) | (0.316) | (0.306) | (0.308) | (0.679) |
| | <0.000> | <0.000> | <0.000> | <0.000> | <0.000> | <0.000> |
| R2 | 0.204 | 0.258 | 0.068 | 0.140 | 0.142 | 0.389 |
| ΔR^2 | | 0.052 | | 0.072 | 0.002 | 0.131 |
| Adjusted R2 | 0.169 | 0.213 | 0.026 | 0.088 | 0.076 | 0.342 |
| F-value | 5.724 | 5.765 | 1.623 | 2.697 | 2.153 | 8.279 |

Note: OLS regression, standardized beta coefficients, standard errors in parentheses, p -values in <> ($n = 71$).

Models 3 to 6 tested Hypothesis 2. Model 3 separately indicated no significant direct relationships between control variables team member proximity ($b = 0.107$, $p = 0.075$), strategic sustainable innovation leadership ($b = 0.090$, $p = 0.265$), and sustainable innovation level ($b = 0.103$, $p = 0.200$) with the mediating variable team empowerment. In Model 4, the inclusion of design thinking practices ($b = 0.199$, $p = 0.021$, $\Delta R^2 = 0.072$) significantly increased the explained variance and showed a positive correlation with team empowerment.

In Model 6, team empowerment was added to the base model (Model 2), resulting in the direct relationship between design thinking practices and team performance becoming non-significant ($b = 0.112$, $p = 0.217$), while the relationship between team empowerment and team performance was significantly positive ($b = 0.472$, $p = 0.000$). Sobel–Goodman mediation analysis results indicated a significant indirect effect (indirect effect $b = 0.094$, standard error = 0.047, $p = 0.045$). Given potential biases in this test, the indirect effect was subjected to 10,000 bootstrap resampling. Bootstrap results were like the Sobel–Goodman mediation test, suggesting significance at a 10% level (bootstrap standard error = 0.051, $p = 0.064$). However, for Hypothesis 3, no support was found, indicating no significant interaction effect between design thinking practices and sustainable innovation level ($b = 0.026$, $p = 0.731$).

4.3. Analysis of Structural Equation Models

The regression analyses revealed direct associations among the variables. Subsequently, path analysis was employed. Leveraging the outcomes of the regression analysis and the coefficients detailed in the report, this study constructed a structural equation model. Validation of path coefficients used structural equation modeling (SEM) (Table 6 and Figure 2). Its objective was to delve into the direct and indirect relationships between the variables, further scrutinizing three hypotheses.

Table 6. SEM results.

| Y | | X | Standard Estimate | Nonstandard Estimate | S.E. | C.R. | p |
|----|------|-----|-------------------|----------------------|-------|-------|-------|
| TE | <--- | DTP | 0.161 | 0.276 | 0.130 | 2.124 | 0.034 |
| TP | <--- | DTP | 0.253 | 0.517 | 0.166 | 3.118 | 0.002 |
| TP | <--- | TE | 0.509 | 0.608 | 0.102 | 5.969 | - |

Note: DTP, design thinking practices; TE, team empowerment; TP, team performance.

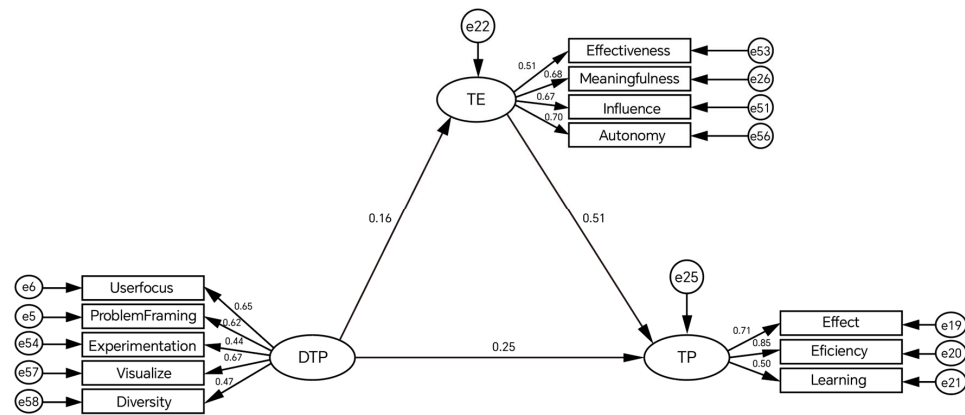


Figure 2. Model relationship diagrams.

We set the independent variable to design thinking practices (DTP), the mediator variable to team empowerment (TE), and the dependent variable to team performance (TP).

Hypothesis 1: direct relationship model

DTP → TP Hypothesis 2: mediation model

DTP → TE → TP Hypothesis 3: moderated mediation model

DTP → TE → TP, where the relationship between DTP and TE may be influenced by the degree of sustainable innovation.

In this model (Figure 2), the impact of DTP on TP includes both direct effects and indirect effects mediated by TE. The basic structure of the model is shown above, and the specific mathematical formula is as follows.

Direct relationship model:

$$TP = \beta_1 \times DTP + \epsilon_1 \tag{2}$$

Among them, TP represents team performance, while DTP represents the direct impact of design thinking practice on team performance, β_1 is the direct impact coefficient, and ϵ_1 is the error term.

Mediation model:

$$TE = \beta_2 \times DTP + \epsilon_2 \tag{3}$$

$$TP = \beta_3 \times TE + \epsilon_3 \tag{4}$$

Among them, TE is team empowerment, β_2 is the coefficient of influence of design thinking practice on team empowerment, β_3 is the coefficient of the impact of team empowerment on team performance, and ϵ_2, ϵ_3 are the error terms for TE and TP, respectively.

Moderated model:

$$TE = \beta_4 \times DTP + \beta_5 \times InnovationDegree + \beta_6 \times (DTP \times InnovationDegree) + \epsilon_4 \tag{5}$$

Among them, InnovationDegree is the degree of sustainable innovation.

Moderated mediation model:

$$TP = \beta_7 \times TE + \beta_8 \times InnovationDegree + \beta_9 \times (TE \times InnovationDegree) + \epsilon_5 \tag{6}$$

In this model, β_6 represents the interaction effect between design thinking practices and the degree of sustainable innovation, and β_9 represents the interaction effect between team empowerment and the degree of sustainable innovation. This model considers the moderating effect of the degree of sustainable innovation on the relationship between design thinking practice and team empowerment, so that the moderating variable plays a moderating role in the mediating process.

Initially, model fit analysis revealed promising results. The chi-square degrees of freedom ratio χ^2/df stood below 3, and most other metrics aligned well, meeting the test values. These findings collectively indicated a strong fit for the model.

The standardized path coefficient from DTP to TE stood at 0.161, exhibiting a statistically significant positive relationship with a p -value below 0.05. This validated the hypothesis of a meaningful influence.

5. Limitations

This study has several limitations that should be considered in future research. Firstly, from a statistical perspective, the number of teams in this study was relatively small. While the focal firm operates across various industries and technological domains, all sustainable innovation projects belong to the same company. Future research should aim to further investigate the application of design thinking practices in various environments, companies, and industries for more reliable results. Secondly, this study focused on team performance in sustainable innovation projects as an indicator of sustainable innovation success. However, this only partially describes sustainable innovation success. Future research should also consider other outcome variables, such as the success of new product development and company performance. Additionally, different research designs, such as comparing the ROI of sustainable innovation activities with and without the application of design thinking practices, are needed. Thirdly, despite using different sources of information to control for potential method biases, the research design does not establish causality. For instance, teams already possessing higher levels of team empowerment may have greater confidence in applying design thinking practices. Future research should further explore the antecedents and consequences of design thinking practices in R&D sustainable innovation projects and other organizational contexts. Furthermore, this study focused on design thinking, and the detailed interactions among various design thinking practices may be an interesting direction for future research.

6. Conclusions

This study examined the consequences of applying design thinking in different contexts and quantitatively demonstrated that design thinking practices are positively related to team performance in sustainable innovation projects. Furthermore, it investigated the mechanisms behind this relationship and revealed that it is mediated by team empowerment. Therefore, this study mainly contributes to the analysis of the impact of design thinking on corporate sustainable innovation capabilities and team performance from three aspects.

Firstly, in contrast to the ambiguity surrounding labels, definitions, and constructs of design thinking, this study independently defined design thinking practices through the application of five core themes of design thinking. As many mechanisms of design thinking have been applied and researched in practice, this conceptualization offers potential for the application of design thinking practices, whether formally or informally. Given the absence of a method to measure this set of practices, the design thinking practices construct in this study was operationalized as an additive scale with five dimensions.

Secondly, this study, using data from a large industrial firm operating across various industries and technological domains, elucidated the relevance of design thinking practices to team performance in sustainable innovation projects. Despite extensive discussions of design thinking in the past decade, this is one of the few pieces of field research that provides quantitative empirical evidence of the benefits of design thinking in sustainable

innovation. Moreover, indications suggest that this benefit is realized through increased team empowerment, as design thinking practices mediate the relationship between design thinking practices and team performance. Thus, it also contributes to the literature on teams, particularly the literature on team empowerment, by showing that design thinking is a precursor to team empowerment. This is particularly interesting, as previously known antecedents of team empowerment, such as team characteristics, job design, leadership, and organizational support, may also interact with design thinking.

Thirdly, although the hypothesis about the moderating effect of sustainable innovation project sustainable innovation level on the relationship between design thinking practices and team empowerment was not confirmed, the inconclusive result raises questions about whether design thinking is more suitable for highly sustainable innovation projects as opposed to incremental or other types of projects. This uncertainty suggests that other factors, potentially internal rather than external factors, may come into play. Thus, this study provides a starting point for discussions in future research.

In addition, this study has also yielded some results in terms of practical significance. Managers should consider introducing design thinking practices cautiously when pursuing clear sustainable innovation objectives. In this study, teams that applied design thinking practices not only demonstrated higher performance but, more importantly, achieved this performance enhancement through increased team empowerment. Therefore, design thinking may facilitate the stimulation of sustainable innovation behaviors, activation of self-organizing capabilities, and support for teams to assume more autonomous responsibilities, especially in environments less accustomed to this way of thinking. For teams facing challenges such as a rapidly accelerating sustainable innovation pace and evolving market demands, design thinking may assist in addressing these challenges. Especially for teams tasked with identifying new products, services, or business models to fill the sustainable innovation pipeline, they must possess the ability to explore unknown territories, act autonomously, make numerous decisions, accept failure, and restart. Therefore, managers should consider creating a safe environment for teams where they have both the freedom and necessary guidance to apply design thinking successfully for sustainable innovation. To enhance team autonomy, an enabling leadership style may be required.

However, design thinking may not be the sole measure to empower teams and achieve sustainable innovation, as this study indicates that design thinking practices can only explain a portion of the variance in team empowerment. This suggests that other factors may be at play.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/su16114428/s1>, Questionnaire Study.

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References

- Brown, T. Design thinking. *Harv. Bus. Rev.* **2008**, *86*, 84. [[PubMed](#)]
- Leavy, B. Design thinking—A new mental model of value sustainable innovation. *Strategy Leadersh.* **2010**, *38*, 5–14.
- Liedtka, J. In defense of strategy as design. *Calif. Manag. Rev.* **2000**, *42*, 8–30. [[CrossRef](#)]
- Chen, Z.; Lam, W.; Zhong, J.A. Leader-member exchange and member performance: A new look at individual-level negative feedback-seeking behavior and team-level empowerment climate. *J. Appl. Psychol.* **2007**, *92*, 202. [[CrossRef](#)]
- Mathieu, J.E.; Luciano, M.M.; D’Innocenzo, L.; Klock, E.A.; LePine, J.A. The development and construct validity of a team processes survey measure. *Organ. Res. Methods* **2020**, *23*, 399–431. [[CrossRef](#)]
- Moreland, K.; Sewell, C.; Usher, W.; Lo, L.T.; Meredith, J.; Pugmire, D.; Kress, J.; Schroots, H.; Ma, K.L.; Childs, H.; et al. Vtk-m: Accelerating the visualization toolkit for massively threaded architectures. *IEEE Comput. Graph. Appl.* **2016**, *36*, 48–58. [[CrossRef](#)] [[PubMed](#)]
- Kirkman, B.L.; Rosen, B.; Tesluk, P.E.; Gibson, C.B. The impact of team empowerment on virtual team performance: The moderating role of face-to-face interaction. *Acad. Manag. J.* **2004**, *47*, 175–192. [[CrossRef](#)]
- Kirkman, B.L.; Rosen, B. Beyond self-management: Antecedents and consequences of team empowerment. *Acad. Manag. J.* **1999**, *42*, 58–74. [[CrossRef](#)]
- Kukenberger, M.R.; Mathieu, J.E.; Ruddy, T. A cross-level test of empowerment and process influences on members’ informal learning and team commitment. *J. Manag.* **2015**, *41*, 987–1016. [[CrossRef](#)]
- Mathieu, J.E.; Gilson, L.L.; Ruddy, T.M. Empowerment and team effectiveness: An empirical test of an integrated model. *J. Appl. Psychol.* **2006**, *91*, 97. [[CrossRef](#)]
- Rapp, T.L.; Gilson, L.L.; Mathieu, J.E.; Ruddy, T. Leading empowered teams: An examination of the role of external team leaders and team coaches. *Leadersh. Q.* **2016**, *27*, 109–123. [[CrossRef](#)]
- Maynard, M.T.; Gilson, L.L.; Mathieu, J.E. Empowerment—Fad or fab? A multilevel review of the past two decades of research. *J. Manag.* **2012**, *38*, 1231–1281. [[CrossRef](#)]
- Seibert, S.E.; Wang, G.; Courtright, S.H. Antecedents and consequences of psychological and team empowerment in organizations: A meta-analytic review. *J. Appl. Psychol.* **2011**, *96*, 981. [[CrossRef](#)] [[PubMed](#)]
- Pistorius, P.A.; Bester, M.N.; Lewis, M.N.; Taylor, F.E.; Campagna, C.; Kirkman, S.P. Adult female survival, population trend, and the implications of early primiparity in a capital breeder, the southern elephant seal (*Mirounga leonina*). *J. Zool.* **2004**, *263*, 107–119. [[CrossRef](#)]
- Carlgren, L.; Rauth, I.; Elmquist, M. Framing design thinking: The concept in idea and enactment. *Creat. Sustain. Innov. Manag.* **2016**, *25*, 38–57. [[CrossRef](#)]
- Lewrick, M.; Link, P.; Leifer, L. *The Design Thinking Playbook: Mindful Digital Transformation of Teams, Products, Services, Businesses and Ecosystems*; John Wiley & Sons: Hoboken, NJ, USA, 2018.
- Carlgren, L.; Elmquist, M.; Rauth, I. Design thinking: Exploring values and effects from an sustainable innovation capability perspective. *Des. J.* **2014**, *17*, 403–423. [[CrossRef](#)]
- Srivastava, A.; Bartol, K.M.; Locke, E.A. Empowering leadership in management teams: Effects on knowledge sharing, efficacy, and performance. *Acad. Manag. J.* **2006**, *49*, 1239–1251. [[CrossRef](#)]
- Carlgren, L.; Elmquist, M.; Rauth, I. The challenges of using design thinking in industry—experiences from five large firms. *Creat. Sustain. Innov. Manag.* **2016**, *25*, 344–362. [[CrossRef](#)]
- Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.Y.; Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J. Appl. Psychol.* **2003**, *88*, 879. [[CrossRef](#)]
- MacKenzie, S.B.; Podsakoff, P.M. Common method bias in marketing: Causes, mechanisms, and procedural remedies. *J. Retail.* **2012**, *88*, 542–555. [[CrossRef](#)]
- Podsakoff, P.M.; Organ, D.W. Self-Reports in Organizational Research Problems and Prospects. *J. Manag.* **1986**, *12*, 531–544. [[CrossRef](#)]
- Chiang, J.L.; Kirkman, M.S.; Laffel, L.M.; Peters, A.L. Type 1 diabetes through the life span: A position statement of the American Diabetes Association. *Diabetes Care* **2014**, *37*, 2034. [[CrossRef](#)]
- Hair, J.F., Jr.; Sarstedt, M.; Hopkins, L.; Kuppelwieser, V.G. Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *Eur. Bus. Rev.* **2014**, *26*, 106–121. [[CrossRef](#)]
- Hoegl, M.; Parboteeah, K.P. Creativity in innovative projects: How teamwork matters. *J. Eng. Technol. Manag.* **2007**, *24*, 148–166. [[CrossRef](#)]
- Worst, K.M.; Hoegl, M.M.; Gemuenden, H.G. Collaboration within and between teams in multi-team R&D projects. In *PICMET’01. Portland International Conference on Management of Engineering and Technology. Proceedings Vol. 1: Book of Summaries (IEEE Cat. No. 01CH37199)*; IEEE: Portland, OR, USA, 2001; pp. 545–552.
- Seidel, V.P.; Fixson, S.K. Adopting design thinking in novice multidisciplinary teams: The application and limits of design methods and reflexive practices. *J. Prod. Sustain. Innov. Manag.* **2013**, *30*, 19–33. [[CrossRef](#)]
- Anderson, N.R.; West, M.A. Measuring climate for work group sustainable innovation: Development and validation of the team climate inventory. *J. Organ. Behav. Int. J. Ind. Occup. Organ. Psychol. Behav.* **1998**, *19*, 235–258.
- Kirkman, B.L.; Tesluk, P.E.; Rosen, B. The impact of demographic heterogeneity and team leader-team member demographic fit on team empowerment and effectiveness. *Group Organ. Manag.* **2004**, *29*, 334–368. [[CrossRef](#)]

30. Elsbach, K.D.; Stigliani, I. Design thinking and organizational culture: A review and framework for future research. *J. Manag.* **2018**, *44*, 2274–2306. [[CrossRef](#)]
31. Talke, K.; Salomo, S.; Kock, A. Top management team diversity and strategic sustainable innovation orientation: The relationship and consequences for innovativeness and performance. *J. Prod. Sustain. Innov. Manag.* **2011**, *28*, 819–832. [[CrossRef](#)]
32. Barger, V.; Peltier, J.W.; Schultz, D.E. Social media and consumer engagement: A review and research agenda. *J. Res. Interact. Mark.* **2016**, *10*, 268–287. [[CrossRef](#)]
33. Hülshager, U.R.; Anderson, N.; Salgado, J.F. Team-level predictors of sustainable innovation at work: A comprehensive meta-analysis spanning three decades of research. *J. Appl. Psychol.* **2009**, *94*, 1128. [[CrossRef](#)] [[PubMed](#)]

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