Virtual hackathons – a novel approach for university-industry collaboration

Jari Jussila[1][0000-0002-7337-1211], Jukka Raitanen[1], Anu Helena Suominen[2][0000-0002-9841-5153], and Anne-Mari Järvenpää[1]

[1] Häme University of Applied Sciences, 13100 Hämeenlinna, Finland
[2] Tampere University, P.O. Box 1001
FI-33014 Tampere University, Finland
lncs@springer.com

Abstract. Pandemics with their lockdowns have proven that radical collocation, collaborating intensively in a same physical space in the same time is not always possible. However, radical collocation is one of the necessary attributes of hackathons, one type of innovation contests. Yet, digital platforms enable virtual collocation, i.e. collaborating at the same time in a virtual place. This paper addresses the virtual hackathon as an innovation contest method for uses in situations, where radical collocation is unfeasible. Specifically, it focuses on virtual hackathon as a method for university-industry collaboration. Although collocation in general plays an integral part in hackathon process, either radical or possible virtual collocation has not yet been the focus of hackathon research. Therefore, this paper presents a case study of a university-industry collaboration involving five organizations in Finland. As a result, the paper reveals benefits, disadvantages and challenges collocation in virtual format causes to the hackathon as an innovation contest event. Presenting conclusions for both academics and industry, the paper contributes to the literature on hackathons used particularly with virtual collocation in the university-industry collaboration.

Keywords: Hackathon, virtual hackathon, university-industry collaboration, radical collocation, virtual collocation

1 Introduction

Pandemics and other global crises, alongside advances in ICT, challenge the organizations of higher education (HE) world-wide. For instance, COVID-19 pandemic locked down a significant amount of schools and higher education institutions around the world and enforced remote learning. In parallel, many industries shifted as much as possible to remote work, by the necessity of governments and cities increased regulation for social distancing. The circumstances challenged how university-industry collaboration can be conducted, while people are unable to meet and interact physically. Virtual hackathons provide one alternative for conducting university-industry collaboration, where universities can e.g. contribute by developing ideas and innovations for industry

This article investigates to what degree virtual hackathons meet the necessary and sufficient features of hackathons, explores the benefits, disadvantages and challenges from virtual collocation compared to radical collocation, and finally outlines benefits that industry can gain by participating in virtual hackathons and giving a challenge to be solved in university-industry collaboration.

2 Theoretical background

2.1 Innovation in university-industry collaboration

Innovation is seldom a straightforward activity. It can be characterized as uncertain, co-constructive, experimental and interactive [1, 2]. University-industry collaboration aims at mutually beneficial knowledge and technology exchange between higher education and industry. Despite the growing interaction between higher education and industry, partners in university-industry collaboration have challenges in utilizing the results of their joint efforts [3, 4]. One root cause for the challenges is that the primary goal of universities is to create open and public knowledge, and provide education [5], whereas industrial partners have strong focus on capturing valuable knowledge that can create competitive advantage that is often directly associated with new product development and innovative functioning of the company [5, 6]. Contradictory objectives, organizational goals and culture have been found to limit the positive effects that can be achieved through university-industry collaboration [7, 8]. Mechanisms and practices for university-industry collaboration include students projects (for example hackathons[9]), thesis projects, tailored degree courses and jointly organized courses [10].

One of the most well-known models of university-industry collaboration is the Triple Helix [11] principle that is based on the institutional triangle of government, business and academia. The entrepreneurial university following Triple Helix principle encompasses a 'third-mission' of economic development in addition to their research and teaching activities [12]. Economic development can, for instance, take the form of developing products and services [13] for business as part of education. Governments can support such activities by, for example, funding research and development projects that involve both business and academia. Hackathons as one type of innovation contest method provides one vehicle how innovations can be developed in university-industry collaboration [14, 15] especially in the front-end of innovation.

2.2 Hackathons

Hackathons, as one type of innovation competition [16, 17], originated among information technology (IT) practitioners [18]. The roots of hackathons date back to MIT in the 1960s, where students gathered together to code in self-imposed 24-hour 'marathon bursts'[18]. From coding the use of hackathons spread to other domains and use cases, [18, 19]. For the purpose of this article, we consider hackathon as *"one type of innovation contest, a short time-bounded event with a challenge to be solved creatively in* *coopetition and with the radical collocation of teams, whose output is recognized in a ceremony at the end of the event."* [14].

Hackathons have also received criticism. The goal achievement of hackathons have been found questionable. The ideas resulting from hackathons are regarded as rarely being effective or adopted in addressing the problems that inspired the hackathons Hackathons have also been found to suffer from a lack of institutional memory [20]. Furthermore, participants have also experienced frustration resulting from expectations about the results of the hackathon. [21] The lack of commercialized results have led [22] to conclude that there is still something missing from the hackathon method.

Virtual hackathons are a new breed of hackathons, where all the the activities take place online, and where the participants are gathered together virtually. Virtual hackathons face the same challenges as 'regular' hackathons, however, operating fully in the virtual space provides also new challenges. The virtual space needs to e.g. accommondate all the participants, enable interactions between them and also provide tools how the participants can work together with the problem and the solution.

2.3. Collocation: radical vs virtual in hackathons

Hackathons are described mainly as an event where participants collaborate intensively [20, 23], during which participants come together and form teams [21, 24–28]. Furthermore, hackathon "implies an intense, uninterrupted, period of programming." [22] and [25] have stated that "the teams are usually collocated". Radical collocation is a situation, where team members are together in a physical space for the duration of the project [25, 29, 30]. Collocation is seen as beneficial for technical work, speeding up software development, facilitating enduring relationships [31] and improving productivity [30]. Also known as a 'war room', radical collocation is seen to help coordination, problem-solving and learning [30]. The physical method of collocation has its benefits in e.g. new product design teams, such as improving communication, building relationships, reducing time involved in design reiterations, and improving project, etc. In physical collocation people communicate via face-to-face communication. In addition to physical collocation, the collocation can be virtual. [32]

In virtual collocation, the members and teams are usually integrated via information and communication technology (ICT), such as personalized ICT tools, e.g. instant messaging, or collective ICT tools, e.g. shared cloud documents [33]. However deploying ICT in collaboration may often results negative aspects, such as misunderstandings, unclear communications, team members' status differences, and the challenges caused by task complexity. The basic differences between physical and virtual collocation is: 1) close vs. remote proximity, 2) the great amount of work and non-work related information vs. minimal informal exchange, which can affect relationship building, 3) increase the opportunity for allocation and sharing both physical and non-physical resources vs. access to resources via ICT infrastructure with its restrictions, 4) control and accountability by monitoring of activities and events and ability to respond to requirements, vs. 'out of sight out of mind' 5) sharing ideas and dilemmas vs. motivational problems of isolation and frustration causing low performance, 6) similar and complementary cultural and educational background vs. variation in both, in addition to time zones and expertise, 7) compatibility vs. incompatibility of the technological systems. [32]

3 Methodology

We chose a case study approach [34] to investigate two virtual hackathons aimed at university-industry collaboration. The cases were purposefully selected based on convenience. The research team consisted of three experienced hackathon facilitators and one hackathon jury member. The hackathons were aimed to create solutions and ideas for industry that were viable, desirable and feasible. The criteria was derived from design thinking and business design [35–37].

First hackathon was aimed at developing a solution for city bikes at the city of Riihimäki. Riihimäki Hackathon examined the maturity of Riihimäki area as a platform for urban cycling. Urban cycling is one among the rising trends in creating city environment. Riihimäki is a city with low cycling modality, where there is limited cycling structure. In addition, the lack of cycling structure and investments in cycling facilities were seen a factor leading to challenges in creating new type of cycling culture. [38] In Riihimäki Hackathon the challenge was formulated by city of Riihimäki and Kaakau Oy, which is a city bikes platform company providing the bikes for Riihimäki and several other cities in Finland. Four teams of students from Häme University of Applied Sciences (HAMK) worked for one day to create solutions to the challenge. The hackathon was facilitated by HAMK Design Factory, an interdisciplinary product and service design and learning platform at HAMK.

The second hackathon was aimed at developing a solution to utilizing surplus fabrics and fabrics with minor quality defects for textile company A. Textile company A**,** located in Forssa develops and procures high quality fabrics having the largest product selection in its market area of workwear, military and outdoor clothing fabrics. The challenge was to understand the regional ecosystem and business ecosystem [39] and create a viable business model utilizing surplus fabrics of textile company A. The solution could involve either an industrial ecosystem or regional ecosystem. Industrial ecosystems create value propositions for specific industry whereas in regional ecosystems the value is created to support the development of certain area [40]. The second hackathon was facilitated by HAMK Design Factory involving student teams from HAMK and Forssa Vocational Institute. In order to understand the benefits that industry can gain by giving a challenge and participating in a hackathon organized in university-industry collaboration interviews of the industry representatives were conducted after the hackathons were completed by email survey. As for increasing understanding on the disadvantages and challenges collocation in virtual format causes to the hackathon observations were performed by two facilitators of the hackathon events and one teacher that participated in the second hackathon. The observation notes and findings were additionally reviewed and discussed with researcher that has also personal experiences of hackathons, but who did not participate in the two hackathons. Investigator triangulation was used to add breadth to the phenomena of interest [41].

4 Results

First, the results portray virtual hackathons evaluated in terms of necessary and sufficient hackathon features. Then the observed benefits, disadvantages and challenges of radical collocation vs virtual collocation are presented. Finally, the results introduce perceived benefits of virtual hackathons perceived by the industry, based on case study interviews. Virtual hackathons evaluated in terms of necessary and sufficient hackathon features [14] are illustrated on Table 1.

Table 1. Evaluation of virtual hackathon against necessary and sufficient hackathon features

Theme	Attribute	Sufficient feature	Case Riihimäki; Case Forssa
Short time-bounded event	Short duration	t<week, ideally 1-3 days	1 day; 1 day
Coopetition	Team	n>1 teams, with 1> members per team	4 teams, 3-5 members/team; 2 teams, 4-5 members/team
	Challenge	Task	Challenge presented and owned by company in both cases
	Creation process	A team formation, creation process	Creating a concept of the solution in both cases
	Ceremony process	An idea pitching jury, possible winner recognition	Both cases had a jury that decided on a winning team
Radical Collocation	Collaboration	Individuals and teams, organizers and participants	Interaction between team members and organizers in Zoom and Teams meetings, collaboration using Teams, Office365 and Google Drive
	Co-location	Separated from daily business, food often served	Virtual co-location via Zoom and Teams meetings, everyone working from home office. Food served on self-service basis
	Consistency	Intensive and consistent	In both cases students were dedicated for completing the hackathon for full day. Interruptions possible.

Based on the necessary and sufficient features of hackathon defined by Halvari et al. [14], we can observe that the two case studies of virtual hackathons met all other necessary and sufficient features except radical collocation. In Zoom and Teams it is possible to have meetings, where you can see live video feed of each team member thus you can have appearance of everyone being virtually present in the virtual space at the same time. However, due to slow network connections of students, teachers and industry representatives participating from home office during the pandemic, it was not possible to have video feed from every participant, rather only from those presenting one at a time. When everyone is participating from home office it follows that there is no opportunity to enjoy meals or refreshments together with the team members and other participants. As a consequence, virtual co-location is disrupted when individual participants take breaks. In situations, where the participants are muted and video is not display it is not possible to determine are the participants actually present unless prompted. Operating from home office opens up also the possibility interruptions that would not similarly occur in radical collocation.

Table 2 summarizes the observed benefits, disadvantages and challenges of radical collocation in contrast to virtual collocation in virtual spaces, such as Teams and Zoom used in the case studies.

Table 2. Benefits, disadvantages and challenges of radical collocation vs virtual collocation.

Theme	Attribute	Benefit	Challenge/Disadvantage
Radical Collocation	Co-location	Physical co-location ensures separation from daily business and family life. Participants can benefit from informal interactions during breaks.	It can be time-consuming and costly to organize people to be physically present at the same location. If co-location, e.g. in the case of social distancing, is restricted it may be impossible to organize co-location.
	Consistency	Coordination of tasks inside team easy when everyone is present and you see what they are working on. Concentration can be more intense when there are not outside interruptions. Facilitators can control the interruptions and optimize workflow.	Getting to know each other and team formation needs to take place physicaly, most often during the event, whereas in virtual environment there are opportunities to interact and comtemplate before the event.
Virtual Collocation	Virtual co-location	Virtual co-location removes the need to travel to venue, which reduces cost and can save time. In virtual spaces new rooms and dedicated spaces can be created instantly and people moved without the physical delay of movement between locations, buildings, rooms, etc. Preparing of	Virtual co-location opens up potential interruptions from business and family life, depending on physical location. In virtual spaces participants can be distracted or even absent from working on shared goals, which may not show on virtual space. Lack of interaction between industry representatives

	presentations for virtual co-location can develop infdustry representatives own understanding.	and participants brings challenges to ensure that the presentation/challenge is understood.
Consistency	People may find it easier to dedicate to virtual hackathon, e.g. participate in introductory talk, mentor teams, present the challenge and participate as jury member when they do not need to reserve time for the full day or duration of the hackathon, but can easily and quickly do their part.	Team members may not be as dedicated to collaboration as there is less social pressure in virtual compared to physical space. Consistency can be disrupted when participants are interrupted or have conflicting activities going on at the same time. Inability to see where, how and on what the team members are working on. Facilitators cannot control the interruptions or optimize workflow as effectively in virtual hackathons

According to the industry representative of Riihimäki Hackathon the hackathon did not yield much direct benefits. It was found interesting to follow the teams work and the results they achieved. However, the results were perceived rather superficial, which could be turned to beneficial outcomes perhaps after a second hackathon. By the point of view of industry representative of Forssa Hackathon, the benefit of virtual collocation was the need to prepare the presentation more carefully, by using simple language and examples to clarify the case. This kind of preparation gave more understanding for the industry representative as well. The challenges related to the fact that the industry representative did not see the participants and because of that, the presenter couldn't get any any visual cues and feedback from the participants' facial expressions and gestures. Because of the lack of interaction, it was difficult for the industry representative to know, did the participants get the point or not. The industry representative proposed two related development ideas. First to prepare the participants beforehand to promote discussion. This could be done by sharing the presentation material of the challenge beforehand for the participants and asking them to prepare questions for the industry representative. Second idea related to the need of seeing peoples faces, at least when they are talking – as well as participants and facilitators. This could create more fluent atmosphere. After the Forssa Hackathon, the giver of the challenge continued university-industry collaboration with HAMK in the form of a tailored course, where student teams of bioeconomy engineering continued to develop solutions for the company following design thinking process [37].

5 Conclusion

This article began with investigation to what degree virtual hackathons meet the necessary and sufficient features of hackathon concept as defined by Halvari et al. [14]. It was found that the necessary feature of radical collation and consistency are not achieved as such in virtual hackathons. This can be interpreted as a need to refine the concept definitions or that virtual hackahtons should be considered as a new type of hackathon concept that is related, but with differences in attributes and design elements.

The exploration of virtual collocation in contrast to radical collocation yielded several insights from facilitators, participants and industry representatives perspective. The results support the findings of Pawar et al. [32] on physical and virtual collaboration on several aspects. From the perspective of both facilitators and teams members it is challenging to monitor the progress of work without physical co-location. Isolation of team members from close proximity can result in motivational problems, reduced performance and also in the case of working from home office provide increased opportunities for interruptions and distractions that would not take place in physical close proximity. Intrestingly, the industry representative also pointed out the lack of seeing facial expressions and bodily gestures of hackathon participants, i.e. lack of visual feedback, as a challenge in communication and collaboration. This insight supports information richness theory [42] and the findings of studies that investigate new media use in collaboration and innovation [43, 44] in this new context of hackathons.

The benefits of short time-bounded events, such as hackathons, were perceived limited by the industry. Hackathons support fast iteration of innovations, mainly yielding new ideas and concepts that can be further developed in slow iteration of innovations. Slow iteration of innovations in university-industry collaboration can be for example thesis projects and research and development projects spanning e.g. 1-3 years. Hackathons, nevertheless, provide universities with the opportunity to increase access and deepen relationships with industry, as is evidenced in the Forssa Hackathon case.

To conclude, virtual hackathons have similarities with the physical hackathons, but they must be planned differently in order to use them efficiently. ICT-tools, selected and prepared virtual environment and facilitation have a key role in making the virtual hackathon successful. The challenges and disadvantages discovered in this study can be used by the practitioners to overcome the most obvious pitfalls of virtual hackathons.

References

1. Edvardsson, B., Tronvoll, B., Gruber, T.: Expanding understanding of service exchange and value co-creation: a social construction approach. J. Acad. Mark. Sci. 39, 327–339 (2011).
2. Jussila, J., Kukkamäki, J., Mäntyneva, M.: Open Data and Open Source Enabling Smart City Development: A Case Study in Häme Region. Technol. Innov. Manag. Rev. 9, 25–34 (2019).

3. Pennacchio, A.B.L.: University of knowledge and firm innovation: evidence from European countries. J. Technol. Transf. 41, 730–752 (2016).
4. Kunttu, L.: Learning practices in long-term university-industry relationships, https://osuva.uwasa.fi/handle/10024/8180, (2019).
5. Lee, K.J.: From interpersonal networks to inter-organizational alliances for university–industry collaborations in Japan: the case of the Tokyo Institute of Technology. R&D Manag. 41, 190–201 (2011).
6. Bruneel, J., D'Este, P., Salter, A.: Investigating the factors that diminish the barriers to university–industry collaboration. Res. Policy. 39, 858–868 (2010).
7. Gomes, J.F., Hurmelinna, P., Amaral, V., Blomqvist, K.: Managing relationships of the republic of science and the kingdom of industry. J. Work. Learn. 17, 88–98 (2005).
8. Kunttu, L., Neuvo, Y.: Balancing learning and knowledge protection in university-industry collaborations. Learn. Organ. 26, 190–204 (2019).
9. Porras, J., Happonen, A., Khakurel, J., Knutas, A., Ikonen, J., Herala, A.: Hackathons in software engineering education – lessons learned from a decade of events. In: SEEM'18, May 27-June 3, 2018, Gothenburg, Sweden. pp. 40–47. Association for Computing Machinery., Cothenburg (2018).
10. Kunttu, L.: Educational Involvement in Innovative University–Industry Collaboration. Technol. Innov. Manag. Rev. 7, (2017).
11. Etzkowitz, H.: Innovation in Innovation: The Triple Helix of University-Industry-Government Relations. Soc. Sci. Inf. 42, 293–337 (2003).
12. Etzkowitz, H., Webster, A., Gebhardt, C., Terra, B.: The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. Res. Policy. 29, 313–330 (2000).
13. Kunnari, I., Ho, T., Nguyen, T.: Rethinking Learning Towards Education 4.0. HAMK Unltd. J. (2019).
14. Halvari, S., Suominen, A., Jussila, J., Jonsson, V., Bäckman, J.: Conceptualization of hackathon for innovation management. In: The ISPIM Innovation Conference – Celebrating Innovation: 500 Years Since daVinci. ISPIM (2019).
15. Suominen, A.H., Halvari, S., Jussila, J.: World Heritage meets Smart City in an Urban-Educational Hackathon in Rauma. Technol. Innov. Manag. Rev. 9, (2019).
16. Hartmann, S., Mainka, A., Stock, W.G.: Innovation contests: how to engage citizens in solving urban problems? In: Civic engagement and politics: concepts, methodologies, tools, and applications. pp. 58–77. IGI Global (2019).
17. Hartmann, S., Mainka, A., Stock, W.G.: Opportunities and Challenges for Civic Engagement: A Global Investigation of Innovation Competitions. In: Civic engagement and politics: concepts, methodologies, tools, and applications. pp. 607–623 (2019).
18. Leckart, S.: The Hackathon Is On: Pitching and Programming the Next Killer App | WIRED.
19. Zukin, S., Papadantonakis, M.: Hackathons as Co-optation Ritual: Socializing Workers and Institutionalizing Innovation in the "New" Economy. Precarious Work Res. Sociol. Work. 31, 157–181 (2017).
20. Briscoe, G., Mulligan, C.: Digital Innovation: The Hackathon Phenomenon. Creat. London. 1–13 (2014).
21. Granados, C., Pareja-Eastaway, M.: How do collaborative practices contribute to

innovation in large organisations? The case of hackathons. Innovation. 00, 1–19 (2019).
22. Komssi, M., Pichlis, D., Raatikainen, M., Kindstrom, K., Jarvinen, J., M. Komssi, D. Pichlis, M. Raatikainen, K.K. and J.J.: What are Hackathons for? In: IEEE Software. pp. 60–67 (2015).
23. Almirall, E., Lee, M., Majchrzak, A.: Open innovation requires integrated competition-community ecosystems: Lessons learned from civic open innovation. Bus. Horiz. 57, 391–400 (2014).
24. Angarita, A.M.M., Nolte, A.: Does it matter why we hack ? – Exploring the impact of goal alignment in hackathons. In: Proceedings of the 17th European Conference on Computer- Supported Cooperative Work: The International Venue on Practice-centred Computing and the Design of Cooperation Technologies - Exploratory Papers, Reports of the European Society for Socially Embedd. pp. 1–15 (2019).
25. Pe-Than, E.P.P., Nolte, A., Filippova, A., Bird, C., Scallen, S., Herbsleb, J.: Designing Corporate Hackathons With a Purpose. IEEE Softw. 15–22 (2019).
26. Gama, K., Alencar, B., Calegario, F., Neves, A., Alessio, P.: Hackathon methodology for undergraduate. In: IEEE Fronties in education Conference (FIE). pp. 1–9 (2018).
27. Rosell, B., Kumar, S., Shepherd, J.: Unleashing innovation through internal hackathons. In: Digest of Technical Papers - InnoTek 2014: 2014 IEEE Innovations in Technology Conference (2014).
28. Kienzler, H., Fontanesi, C.: Learning through inquiry: a Global Health Hackathon. Teach. High. Educ. 22, 129–142 (2017).
29. Pe-Than, E.P.P., Herbsleb, J.D.: Understanding Hackathons for Science: Collaboration, Affordances, and Outcomes. In: Taylor, N.G., Christian-Lamb, C., Martin, M.H., and Nardi, B. (eds.) Information in Contemporary Society, Proceedings of 14th International Conference, iConference. pp. 27–37. Springer, Washington, DC, USA (2019).
30. Teasley, S., Covi, L., Krishnan, M.S., Olson, J.S.: How does radical collocation help a team succeed? In: AMC conference on CSCW 2000. pp. 339–346. , Philadelphia, PA, USA (2000).
31. Trainer, E.H., Kalyanasundaram, A., Chaihirunkarn, C., Herbsleb, J.D.: How to Hackathon: Socio-technical Tradeoffs in Brief, Intensive Collocation. Presented at the February (2016).
32. Pawar, K.S., Sharifi, S.: Physical and virtual collaboration in new product development: A comparative analysis. 2017 Int. Conf. Eng. Technol. Innov. Eng. Technol. Innov. Manag. Beyond 2020 New Challenges, New Approaches, ICE/ITMC 2017 - Proc. 2018-Janua, 997–1002 (2018).
33. Lohikoski, P., Kujala, J., Härkönen, J., Haapasalo, H., Muhos, M.: Enhancing Communication Practices in Virtual New Product Development Projects. Int. J. Innov. Digit. Econ. (2015).
34. Siggelkow, N.: Persuation with Case Studies. Acad. Manag. J. 50, 20–24 (2007).
35. Plattner, H., Meinel, C., Leifer, L.: Design thinking : understand - improve - apply. Springer, New York (2010).
36. Faljic, A.: The Ultimate Business Design Guide. d.MBA (2019).
37. Jussila, J., Raitanen, J., Partanen, A., Tuomela, V., Siipola, V., Kunnari, I.: Rapid Product Development in University-Industry Collaboration: Case Study of a Smart Design Project. Technol. Innov. Manag. Rev. 10, (2020).

38. Félix, R., Moura, F., Clifton, K.: Maturing urban cycling: Comparing barriers and motivators to bicycle of cyclists and non-cyclists in Lisbon. J. Transp. Heal. 15, (2019).
39. Pulkkinen, J., Jussila, J., Partanen, A., Trotskii, I., Laiho, A.: Smart Mobility: Services, Platforms and Ecosystems. Technol. Innov. Manag. Rev. 9, 15–24 (2019).
40. Den Ouden, E.: Innovation design: Creating value for people, organizations and society. Springer Science & Business Media. (2011).
41. Denzin, N.: Sociological methods: A sourcebook. McGraw-Hill., New York, NY (1987).
42. Lengel, R., Daft, R.: Information richness: A new approach to managerial behavior and organization design. Res. Organ. Behav. 6, 191–233 (1984).
43. Jussila, J.J., Kärkkäinen, H., Leino, M.: Learning from and with customers with social media: A model for social customer learning. Int. J. Manag. Knowl. Learn. 1, 5–25 (2012).
44. Dennis, A.R., Kinney, S.T.: Testing media richness theory in the new media: The effects of cues, feedback, and task equivocality. Inf. Syst. Res. 9, 256–274 (1998).