ISSN 1980-5411 (On-line version)
Production, 33, e20220099, 2023
DOI: 10.1590/0103-6513.20220099

Research Article

Action research supported by remote collaboration tools: analysis of two operations management applications

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Abstract

Paper aims: This paper aims to discuss how Remote Collaboration Tools (RCT) can support and contribute to Action Research (AR) applications in operations management research.

Originality: Researchers shall capture the complexity of studied phenomena when conducting AR. Although, there is a lack of information regarding the use of RCT in AR. Hence, this paper provides original and comprehensive guidelines for the application of RCT in AR.

Research method: This paper provides an ex-post analysis of two face-to-face AR cases, based on the steps proposed by Coughlan and Coughlan (2002). Based on the ex-post analysis, it explains ex-ante and how RCT can impact and contribute to AR on operations management.

Main findings: The paper presents reflections, insights and guidance about the impacts of RCT in AR. RCT allow possibilities for continuity and efficient use of resources in AR. Although, when choosing RCT, special efforts should be put into team building and engagement.

Implications for theory and practice: The description of how the RCT can be used in the AR cycle can contribute to theory based on empirical results as guidance to increase value considering AR quality criteria. We intend to provide material for the advance of the field of Operations, Production and Management, theoretically and practically.

Keywords:
Digital tools. Remote work. Collaboration. Research method. Production.

How to cite this article: Souza, J. P. E., & Muniz Junior, J. (2023). Action research supported by remote collaboration tools: analysis of two operations management applications. *Production*, *33*, e20220099. https://doi.org/10.1590/0103-6513.20220099

Received: Aug. 24, 2022; Accepted: Apr. 17, 2023.

1. Introduction

It is becoming more important for researchers to observe reality as directly as possible, especially for developing rather than testing theory. To directly observe the phenomenon under study, there is a call for research methods such as case and field-based studies, AR, and other field experiments (Craighead & Meredith, 2008). Although, the emergence of digital platforms upon which people use various channels to interact, watch others interact, share, build and understand common knowledge, known as remote collaboration tools (RCT), increased its use in recent times mainly due to the COVID-19 pandemic. Then, it required the investigation of the effects of the use of RCT in research practices. Consequently, if operations management researchers decide to use RCT to investigate the studied phenomena they shall understand the impacts of its use. Considering the research methods used in operations management research, AR researchers intend to test their theory on the organisation's real situations, get feedback from experience, refine the theory with that feedback, and (re)test again. Consequently, AR researchers are challenged to be participating in real-life situations.

While many AR researchers were used to conducting AR activities face to face, the COVID-19 pandemic mobility and meeting restrictions caused the interruption of some AR research projects. The need to reduce physical interactions during the COVID-19 pandemic has boosted digital transformation in many forms, causing the adoption of new channels of communication with various stakeholders (Micheli et al., 2021). Subsequently, video conferencing capabilities (Bertrand & Bourdeau, 2010; Sullivan, 2012) and remote work management tools (i.e. Trello, Monday, slack, etc) were spurred to minimize the restrictions on face-to-face activities. Initially, most people were not ready and eager to use RCTs. Consequently, there is a problem with the lack of information on the impacts, possibilities and necessities of the use of RCT as a solution for the restrictions on face-to-face activities and a possibility for the continuity of AR activities. Additionally, with the ease of the pandemic restrictions, the lessons learned foster the possibility of using the knowledge to allow the research community to deal with new research challenges and be more efficient in conducting AR activities. Thus the research question is: What are the impacts, implications and opportunities for the conduction of AR activities applying RCT?

AR's literature has grounded theoretical and philosophical arguments (Carr, 2006; Avison et al., 1999; Wicks & Reason, 2009; Kemmis, 2010; Flood, 2010; Altrichter et al., 2002). However, AR literature is replete with discussions and argumentation about its origins, philosophies and conceptual underpinnings; there is a lack of guidance on ``how-to-do" AR (McKay & Marshall, 2001:49). Additionally, Coughlan & Coghlan (2002) provided a well-known contribution for a definition of the AR cycle and the steps to implement AR in operations management (see Figure 1). Although it does not approach the specific challenges of conducting AR using RCT. For example, Schmidt-Jones (2020) applied online AR methodology with a focus on remote application, including open versus closed online actions, although his proposal does not cover structured AR steps. Indeed, practitioners and academics still need structured steps such as those proposed by Coughlan & Coghlan (2002). Building on existing methodological contributions (Avison et al., 1999; Altrichter et al., 2002; Coughlan & Coghlan, 2002; Miguel, 2007; Mello et al., 2012; Nakano & Muniz Junior, 2018; Wintersberger & Saunders, 2020), this research aims to offer the production management community a guide to a current relevant aspect of research methods: the conduction of participative field research supported by RCT. This paper contributes to providing knowledge and a viable alternative to researchers to use RCT to explore better the action research method in management and multidisciplinary studies as a key approach to generating knowledge, learning, and transformative organisational change and development considering the nature of quality in action research practice. Also, the paper offers to the action research community, including both academics and professionals, a guide to the conduction of AR activities supported by RCT.

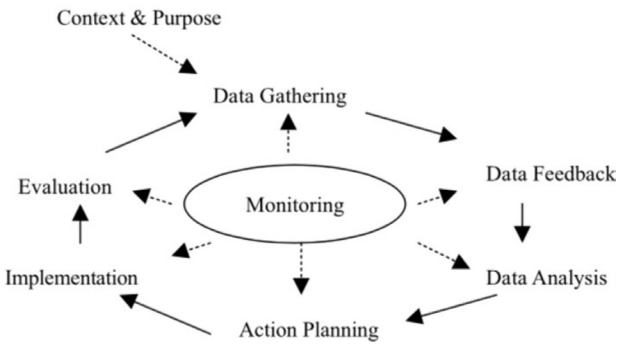

Figure 1. Action Research steps (Coughlan and Coghlan, 2002).

This paper aims to investigate how RCT can impact AR. To investigate the impacts of conducting AR activities remotely, it considers the steps of the AR method and the use of RCT for the support of AR activities. Additionally, it also addresses the operational implications related to AR adoption and uses in multidisciplinary studies as a key approach to generating knowledge, learning, transformative organisational change and development in social systems. It also describes the pros and cons as guidance to support AR to increase value considering the nature of quality in action research practice based on the steps proposed by Coughlan & Coghlan (2002). This contribution, provides material for the advance of the field of management research, theoretically and practically.

Aware of the challenges involved in conducting AR, this paper approaches the use of RCT in AR activities and their methodological and operational implications.

This paper is structured as follows. Section 2 presents the Action Research method based on Coughlan & Coghlan (2002), and Section 3 shows the RCT. Thereafter, Section 4 presents the analysis of the potential effects of the incorporation of RCT on the conductions of AR. Finally, Section 5 concludes, with practical and theoretical implications, and indicates future research.

2. Literature review

2.1. Action research

AR is a research method that aligns academic and organisational interests to solve complex organisational problems that represent theoretical contribution, knowledge and learning. Hence, AR is conducted through iterative and interactive questioning through sequential cycles of activities involving planning, action, observation, and reflection on the phenomenon studied in partnership with academic and organisation representatives (Altrichter et al., 2002, p. 130, Avison et al., 1999, p. 94, Shani & Pasmore, 1985, p. 439). The role and potential impact of collaborative communities of inquiry and progressing beyond the traditional methods foster opportunities for action research to contribute to their implementation and the generation of useful knowledge (Shani & Coghlan, 2019).

AR received criticism regarding its use in the generation of scientific knowledge from the classical perspective of science (Carr, 2006). To circumvent them the researcher must focus on two objectives or "imperatives" (McKay & Marshall, 2001, p. 46): (a) solve a practical problem within an organisation by making a direct contribution to transforming ongoing action and changing its historical context and (b) generating new knowledge and understanding about other organisations. For instance, AR researchers intend to test their theory on the organisation's real situations, get feedback from experience, refine the theory with that feedback, and (re)test again. Consequently, AR researchers are challenged to be participating in real-life situations.

AR occurs when people act together deliberately to improve or develop their contexts, with a close interrelationship between their reflection and action, and a public report of this experience is produced (Altrichter et al., 2002, p. 130). Member engagement must generate a "critical community" with autonomy for self-reflection, self-evaluation and self-management, with collective and progressive learning by doing and making mistakes. Coughlan & Coghlan (2002) cited Gummesson (2000) to substantiate the main characteristics of the AR:

- Alignment between problem-solving and contribution to science;
- It requires a preliminary understanding of the studied context, the characteristics of the organisational, the structure and dynamics of the operating systems and the theory involved;
- Researchers take part in the action, not only observing the people who took it, they actively working to make the actions happen;
- Cooperation between researcher and workgroup (co-researchers) to continually adjust to contingencies, new information and occurrences;
- It may include traditional methods of obtaining data, such as interviews, focus groups and surveys. The planning and use of these methods can engage the members of the researched organization;
- Help develop a holistic understanding during research and characterisation of its complexity;
- Researchers need to have a broad knowledge of how the system works and be able to move between formal and technical structure (explicit knowledge) and people's informal subsystems (tacit knowledge);
- Applicable for understanding, planning and implementing organizational changes;
- Need attention to the ethical structure, values and norms of the studied context;
- It must be conducted in real-time as it is a "live" reality showcase.

Additionally, AR contributes to the development of participants' practical situations and competencies, in line with organizational objectives (Altrichter et al., 2002, p. 127; Avella & Alfaro, 2014). Carson et al. (2001, as cited in Perry & Gummesson, 2004), indicate that traditional AR involves:

(1) a group of people who use cycles of activities that involve planning, acting, observing, and reflecting on what is happening;

(2) the attempt to reflect and improve on the workgroup actions and processes;

(3) assistance in solving complex and practical problems about which little is known;

(4) producing a report to the working group organization on what was found.

AR is a challenging approach to researchers because it requires confidence and experience to cope with the uncertainty of the unfolding story and the ability to work exposed to the reality of organisational change in real-time. Consequently, it requires skills in diagnosis and intervention concerning issues and problems in organisations. Although, it is also important to consider if research conditions pose any additional challenges. For example, if researchers decide to use RCT, the impacts and needs of its use must be known and considered to assure the quality of investigation of the studied phenomena they shall consider the impacts of its use. In an AR, the emphasis is more on the action conducted in partnership with the researchers and the practitioners with a focus on observation of what the working group do and less want they say to do. Another characteristic of this partnership is characterised by a two-way relationship of interest, in which the researcher becomes involved in contributing to the practical world, and the researcher becomes involved in contributing directly to the research outcome. Consequently, it is necessary to assure the quality of the communication and interaction for the observation of the phenomena by the academic and organisational teams. Hence, it is necessary to have adequate methods and tools for conducting the steps of an AR. Next, we present the AR steps proposed by Coughlan & Coghlan (2002).

2.1.1. Action research steps by Coughlan and Coughlan

Based on the fundamental methodological question of 'How can operations managers and researchers learn from the applied activity that characterises the practice of OM?' Coughlan & Coghlan (2002) outline the AR cycle and its steps (Figure 1) for its implementation.

2.1.1.1. Pre-Step - context & proposal

As an initial step, Coughlan & Coghlan (2002) propose familiarisation with organization characteristics. Hence, an analysis shall be carried out by researchers about the organization and its socio-technical systems, to learn about the contextual environment, which may include participation in the meetings. It allows researchers to "immerse" in the organizational routine, and familiarize themselves with the processes and professionals involved with the activities.

2.1.1.2. Step I - data gathering

Subsequently, the next step consists in collecting the data needed for the AR. It is important to differentiate "hard"' data from "soft" data. Hard data can be gathered through operational statistics, financial data, financial accounts and marketing reports. Thus, there is the ``soft" data that can be gathered through observation, discussions and interviews. It is important to be aware of the fact that these data are largely perceptual and may be difficult to interpret validly.

During the data generation, the researcher is involved actively in the organisational activities relating to the AR project. Some of these observations and interventions of the researcher are made using formal settings, such as meetings and interviews; and others are made in informal settings, like over coffee, lunch and other recreational settings. Additionally, directly observable characteristics are an important source of data for the action researcher. Particularly, observations of the dynamics of groups at work (e.g. communication patterns, leadership behaviour, use of power, group roles, norms, elements of culture, problem-solving and decision-making, and relations with other groups). So, the action researcher is dealing with directly observable phenomena in the organisations with which they are working.

2.1.1.3. Step II - data feedback

After collecting data, the action researcher shares it with the organization to make it available for analysis in the feedback meetings.

2.1.1.4. Step III - data analysis

Subsequently, for data analysis in AR is expected collaboration between the researcher and members of the organisation (i.e management team). This approach assumes that employees know their organization best, know

what will work and, ultimately, will implement and follow through on actions taken. Hence, the involvement of those employees is critical.

2.1.1.5. Step IV - action planning

After the analysis, the next actions are planned as a joint activity. The AR steering group set who does what and an appropriate time schedule.

2.1.1.6. Step V - implementation

The organization implements the planned action, which involves making the changes and following the plans in collaboration with relevant organization members.

2.1.1.7. Step VI - evaluation

Finally, it is time to reflect on the outcomes of the action, both intended and unintended. This evaluation involves a review so that the next AR cycle may benefit from the experience of the cycle completed. The evaluation step is the key to learning and generating knowledge. Hence, without evaluation actions can go on regardless of success or failure and consequently errors can be proliferated and ineffectiveness and frustration increase.

2.1.1.8. Meta-step: monitoring

Hence, during the AR cycle monitoring is a meta-step that occurs through all the cycles. In short, each AR cycle leads to another cycle (Figure 1), and so continuous planning, implementation and evaluation take place over time, which includes continually monitoring each of the six main steps. While the steering group focuses on the organization's project outcomes, the researcher is concerned with how the project is working, and also with the learning process.

Action Research requires quality criteria, which are guided by the following questions (Reason & Bradbury, 2001 apud Coughlan & Coghlan, 2002):

- Does the survey reflect the cooperation between the researcher and the members of the organization?
- Is the research guided by a reflection on the practical results?
- Does the research include a plurality of learning that ensures theoretical and conceptual integrity, ways of learning and methodological property?
- Is Research aligned with relevant work?
- Will research result in sustainable and effective change?

Hence, classic AR is conducted "essentially" in the place where things happen and in real-time. Although, the COVID-19 pandemic has brought to light a new reality composed of limitations to mobility and physical presence. Considering the Covid-19 pandemic not only as an "interference" of a linear trajectory but as a turning point for the conduction of research activities, regarding the adoption of specific practices, and also to potentially considerable and long-lasting shifts in researchers' and practitioners' perceptions (Micheli et al., 2021). Consequently, to the continuity of the conduction of AR activities impacted by limitations to mobility and physical presence, RCT can play an essential role in overcoming the limitations by offering a solution for the continuity of AR activities.

2.2. Remote collaboration tools

The conduction of AR activities involves dealing with hard and soft data. Particularly, when dealing with soft data, it is largely perceptual and may be difficult to interpret validly (Coughlan & Coghlan, 2002). While technology can pose limitations to the conduction of activities it also can pose opportunities, as working asynchronously across time and space may enable rich and complex conversations (Crowther et al., 2021). The use of RCT for discussions and interviewing can bring great advantages regarding cost and time efficiency. On the other hand, it can be difficult to interpret the validity of subtle perceptions. The use of RCT calls for a

clear awareness of the action researcher to the fact that the lack of proximity with the research group can make it harder to capture some subjective aspects that could arise during the research.

As a solution for mobility and meeting restrictions, RCT can be a solution. For example, online interviewing can increase the participants' flexibility regarding time and location (James & Busher, 2016). Additionally, RCT can provide access to hard-to-reach units of analysis such as business travellers and professionals who have complex office schedules (Rezabek, 2000). Interviewing using RCT may also offer a comfortable and convenient way of collaborating in research (Edmunds, 1999), which includes people who may be part of the research without having to leave their places. Although, James & Busher (2016) mention some disadvantages of using RCT, such as the possible existence of interruptions during the conversation product to low-quality connection (if it is an online synchronic interview); an increase in the participants' distraction level; unequal access to the Internet; or disappearance/limitations of the participants' non-verbal language.

Hence, RCT can offer support for virtual research activities. Table 1 presents types, descriptions and examples of RCT.

Table 1. Remote collaboration tools.

Remote collaboration tool	Description	Examples
Project Management Tools	A collaboration tool that organizes your projects into visual aid boards to improve visualisation and communication.	Trello, Monday,
Schedule interviews	Online scheduling tool used to decide on a date and time for a meeting between a group of people	Doodle
Web pools	Create and analyse surveys in a mobile or web browser. It allows you to get instant results, as they come in and summarizes results into charts and graphs.	Survey Monkey, google forms
Web meetings	A video conferencing service is a solution for both individuals and businesses to meet on audio and video calls.	Google Meet, Teams, Skype, Zoom
Online Scheduling Tools	Online scheduling tools are used to facilitate the process of finding a date and time for a meeting or event.	Doodle
Interviews transcription tool	Assists researchers, scholars, and students in converting speech to text. The software transcribes and identifies each speaker's speech separately.	Nuance, Tactiq, Transcript
Cloud file sharing	Refers to a range of cloud services that allow people to store and synchronize documents, photos, videos and other files in the cloud—and share them with other people. These services also allow users to share and synchronize data among multiple devices for a single owner.	Google Drive, Dropbox, Microsoft OneDrive
Virtual Whiteboard	Provide teams with a solution on which they can work remotely, from everywhere. A whiteboard aims to visualize thoughts and concepts, write down ideas, explain and teach, plan and create collaboratively. Online whiteboards can be used for the same purpose as a real whiteboard but without the limitations of a real whiteboard. Allows the construction of a virtual post-it wall where insights and captured knowledge can be added anytime, avoiding loss of information during the waiting between knowledge identification and report meetings.	Miro, Jam
Web-based document management	A platform for creating and editing private and public, word processing and spreadsheet documents	Google Docs, Microsoft 365
Instant messaging tools	Provides a single place for messaging, tools and sharing files.	Slack, WhatsApp, Skype, Microsoft Teams, Telegram
Data Visualisation tools	Collection of software services, apps, and connectors that work together to turn your unrelated sources of data into coherent, visually immersive, and interactive insights.	Power BI, Tableau, Plotly, Excel, Zoho analytics
E-mails	A typed message that is sent from a computer, a phone or another mobile device.	Gmail, Hotmail, Yahoo, etc.

In the following section, we present two cases of AR conducted in a face-to-face setting as a base to explore the possibilities of the use of RCT.

3. Ex-post analysis of AR cases to support the ex-ante description of how RCT can impact and contribute to AR in operations management

The COVID-19 pandemic caused restrictions to mobility and face-to-face activities and caused the interruption of some AR activities. Consequently, there is a call for solutions for the continuity of AR activities. Here we present

the description of two AR cases that followed the steps proposed by Coughlan & Coghlan (2002). Those two AR cases were conducted in an operations management context using face-to-face activities. Thus performed an ex-post analysis to investigate the possibilities and necessities of the use of RCT as a solution for the restrictions on face-to-face activities for the conduction of AR activities. Although most of the COVID-19 pandemic restrictions are eased, there is an opportunity to reap the knowledge and lessons provided by the ex-post analysis to provide an ex-ante reference to allow the research community to be prepared to deal with the new research challenges and be more efficient in conducting AR activities such as interviews, data collection, discussion and analysis.

To investigate the impacts of conducting AR activities using RCT, we considered the steps of the AR method proposed by Coughlan & Coghlan (2002) for the conduction of an ex-post analysis of how RCT could impact and contribute to AR in operations management. Additionally, it also considered the operational implications related to AR adoption and uses in multidisciplinary studies as a key approach to generating knowledge, learning, transformative organizational change and development of social systems. To perform the ex-post analysis this paper uses two AR cases conducted previously by the authors. Next, we detail the two AR cases:

- Case 1 investigates the integration of quality, environmental, social responsibility and occupational health and safety management systems with lean manufacturing to improve corporate sustainability in an aerospace manufacturing organisation. The academic team was composed of a PhD candidate and his supervisor. The organisation's team was composed of the integrated management-system manager and two continuous improvement analysts. The organization also had the participation of representatives such as the plant director, the environmental-management-system focal point, the occupational-health and safety management-system focal point and three production supervisors, the human resources manager and the logistics supervisor (Souza & Alves, 2018).
- Case 2 evaluates factors that support workers' tacit knowledge-sharing in a glass manufacturing organisation, based on the judgement of blue-collar workers and managers. The academic team included two researchers and one research assistant. The organization team was composed of the Technical Training Manager, HR Supervisor, and employees who work directly with the blue-collar workers from the following departments: Research and Development, Human Resources, Glass Production (2), Glass Decoration, Machine and Devices Production and Logistics totalling a multidisciplinary team of 13 employees. There was also the involvement of managers and directors of the organisation in the critical analyses involved in the course of the reported research (Muniz Jr. et al., 2019).

Next, the two AR cases are summarized in Table 2, with the correlation with the AR steps and the indication of possible uses of RCT. Additionally, it is presented the pros and cons that could arise from the use of RCT.

Considering that Action Research requires its quality criteria (Reason & Bradbury, 2001 apud Coughlan & Coghlan, 2002), the pros and cons of the RCT in Table 2 help to evaluate the AR quality criteria:

- Does the survey reflect the cooperation between the researcher and the members of the organisation?
- i.e. The RCT supported cooperation between the academic and organisation teams in the AR.
- Is the research guided by a reflection on the practical results?
- i.e. Academic research was conducted based on the reflections performed during the Monitoring (Meta-step). The Virtual Whiteboard and web meetings supported reflection on the practical results by the academic team during the Monitoring (Meta-step).
- Does the research include a plurality of learning that ensures theoretical and conceptual integrity, ways of learning and has methodological properties?
- i.e. The research described the plurality of learning during the Monitoring (Meta-step) ensuring focus on the AR method together with theoretical and conceptual integrity brought by the academic team. By the use of RCT, such as virtual whiteboards and data visualisation tools, the plurality of learning could be increased by the possibility of better capturing and consideration of team members' opinions and knowledge.

Considering the importance of the ethical issues for the quality of an AR, it is relevant to discuss the ethical implications to be considered during the conduction of an AR. When conducting an AR, it is expected researchers engage with a group to mutually identify a problem and its sources, and then negotiate contextualised solutions (Blake, 2007). Furthermore, the use of RCT can allow AR teams to engage more frequently to help to identify problems and their sources and also contextualised solutions. AR diverges from the scientific tradition of the researcher's subjectivity in the relationships between the researcher and the researched. Consequently, performing AR involves the researcher's active interaction and participation in the organisation's team group activities, which

Table 2. AR Steps and RCT.

AR Step	Case 1 Description	Case 2 Description	Opportunities for remote collaboration
Context & Proposal	During the pre-step to understand context and purpose, there were meetings to align the organisation and academic rationale for the AR. Despite the company stating that the project to improve its corporate sustainability performance is necessary, the company presented initial resistance to the implementation of actions and new practices or changes to the actual ones. During the initial stages of the AR, the organisation's team showed motivation and was considerably easy to put the teams together in face-to-face meetings.	The pre-step was conducted by the academic team to discuss the context and the research proposal. It was carried out face-to-face to discuss organizational issues related to the shop floor of the glass sector, concepts, and research gaps. During the first two weeks, the researchers focused on immersing in the shop floor context and production activities in different shifts with active involvement in the day-to-day organisational processes. This immersion allowed the integration of the researchers with the blue and white-collar, observation of group roles, culture, and decision-making. Some of these observations were made during formal events like meetings and interviews; many were made during informal events during coffee and meals.	**Web pools** pros - collect data from a broader sample spending less money and time. Could provide more security for respondents to provide anonymous answers. cons - avoidance of registering sensitive information formally. Usually, the tax on responses is low. **Web meetings** pros - cost and time more effective. cons - does not support the construction of a deeper relationship between the teams and participants. Does not capture subtle and non-intentional communication (such as body language). Some valuable information can be collected during unplanned informal activities, such as coffee breaks, talks and lunchtime. Such information would not be collected if web meetings were used. **Interviews transcription tool** pro - quicker and more accurate transcriptions. cons - would be prohibitive because the company had the policy to prohibit recordings. **Cloud file sharing** Pros - could allow synchronous and non-synchronous collaboration. cons - the company had the policy to prohibit document sharing outside its internal network. **Virtual White Board** pros - could allow synchronous and non-synchronous collaboration.
Data Feedback	The process of Data Feedback encountered difficulties due to the lack of available time for the organisation's team. The data feedback step was performed using face-to-face talks, meetings and document evaluation for validation of the collected data.	The data feedback includes validation of the content of answers with each interviewee. We transcribed the interviews manually and validated the transcribed answers with each interviewee. Normally they agreed with the text, but there were some requests for the inclusion or exclusion of text.	The use of RCT can be more time and cost-efficient and foster the quality of the data feedback through the increased opportunity for communication by the teams. **Interviews transcription tool** pro - the transcriptions are more quickly available for validation with the interviewees. **Web meetings:** pro - After the transcription, the researchers and interviewees can review the transcription playing back the video and/or audio and, if necessary, make revisions. **Cloud file sharing:** pro - share the gathered data directly with the interviewees for validation. con - recorded data, including personal or sensitive, requires special protection actions. **Instant messaging tools:** pro - the use of instant messaging tools could have helped significantly the communication process. **Virtual Whiteboard:** pros - allows collaboration of the team to analyse data with more time and cost efficiency.
Data Analysis	After performing the Data Feedback step, the academic and the organisation team performed the Data Analysis together. The first issue was related to the harmonization of the tools and criteria for data analysis by the academic and organizational teams. Both teams needed to have a compatible level of understanding of the tools and criteria to do the analysis together. Although, the academic team had to deal with the avoidance of the organisation's team considering and reporting negative results. It called for higher attention from the academic team to keep the data accurate and unbiased during the analysis of data. Additionally, it is important to highlight that the organisation's team knows their organisation best, knows what will work and, ultimately, will be the ones to implement and follow through on whatever actions will be taken. But, on the other hand, it was identified resistance to new tools and criteria for data analysis.	The Data analysis was carried out with a discussion between the organisation and academic teams about the mapped factors. It applied content analysis software to analyse the answers to map factors related to worker knowledge sharing in the glass industry and analysis of the factors based on studies from the literature. The data collected on the questionnaire allowed the evaluation and analysis of the factors related to worker knowledge sharing. From this evaluation, two main focus areas were identified: (i) "importance" given by the professional to the proposed factors and (ii) "attention given by the Company" to the respective factors.	**Data Visualisation tools / Virtual Whiteboard / Cloud file sharing:** pro - the use of data visualisation tools and cloud file-sharing could have allowed each team to evaluate the data asynchronously and in different locations. cons - individual modifications of the data analysis could embed bias or difficult use of new data analysis tools. **Web meeting:** pro - on synchronous analysis allows recording the discussion that supports the findings.

Table 2. Continued...

AR Step	Case 1 Description	Case 2 Description	Opportunities for remote collaboration
Action Planning	During the Action Planning, the activities were planned as a joint effort between academic and organisation teams. The action planning process considered the necessity of action related to sustainability management. But considering that the organisation's team had many restrictions due to involvement in other projects and activities it caused difficulties in conducting the action planning process. The action planning process is described: - the types of change; - what needs to change; - who will support the change; and - which parts of the organization need change. Resistance to the required changes to implement a sustainability management system was observed. Consequently, an additional plan to deal with the resistance to changes was added to the action plan.	For the action planning process, we considered the two main focus areas identified in the data analysis: (i) "importance" given by the professional to the proposed factors and (ii) "attention given by the Company" to highlight those areas for discussion and prioritisation of actions. These actions search to improve worker knowledge sharing on the shop floor. These actions involve different departments, and it was validated by managers and directors.	**Project Management Tools:** pros - could have brought significant support to organise, distribute, communicate and provide work visibility. Allowing a co-creation process could have reduced the resistance to change proposed by the academic team. cons - if one of the teams is not familiar with the tool, additional time is needed for training in the new tool. **Online Scheduling Tools:** pro - the use of online schedule tools could have saved time spent on finding a common agenda for the meetings and assuring more participation of the people involved in the project. **Web meeting:** pro - engage from different places to discuss actions and impacts cons - keep the focus of the team members for a long time
Implementation	Once actions were planned, the organisation's team implemented the actions with supervision and frequent feedback from the academic team. It was observed that remote* feedback about the implementation from the organisation's team using e-mail or phone calls was not enough to allow the academic team to analyse the effective implementation and allow proper reflection on the process. Consequently, it was necessary to perform the implementation on the site using face-to-face activities.	The actions were implemented following the action plan. Follow-up meetings were conducted by academic and organisation teams on regular bases to support the progress of the action plan.	**Project Management Tools** Pros - could have brought significant support to organise, distribute and communicate the planned activities. Additionally, could have helped to manage and provide work visibility of action execution between both teams. **E-mails** cons - It was observed that the simple remote feedback from the organisation's team about the action execution was not enough to allow the academic team to analyse the execution and output details. **Web meetings** pros - can be more cost and time-efficient. cons - the organisation's team showed to be more open to reporting results when on face-to-face interactions. * At the time the actions of case 1 were implemented (the year 2015) the team was not familiar with the actual RCT. Considering the actual knowledge and experience of the teams using RCT probably would be possible to conduct the implementation step remotely.
Evaluation	The evaluation and subsequent reflection on the outcomes of the actions allowed both teams to identify if the action was successful or not and if not why? This learning process led to improvements in the next AR cycle. It was observed that the identification of negative outcomes was more open and effective when using face-to-face activities than when using conference calls or email reporting.	The outcomes of the implemented actions were evaluated by managers to identify the need for improvements, constraints, and the need for a new AR cycle. From the evaluation step, it was identified the need to expand the sample restarting the evaluation of the plants based on two main focus areas, to assess the plants and identify progress and opportunities for improvements.	**Web meetings** pros - can be more cost and time-efficient. engage from different places to discuss actions and impacts cons - the report of negative outcomes can be less open and effective when using web meetings than when using face-to-face activities. **E-mails** cons - It was observed that the report of negative outcomes was more open and effective when realised personally when compared with email reporting. **Data Visualisation Tools / Virtual Whiteboard:** pro - the use of data visualisation tools could have allowed each team to evaluate the data asynchronously and in different locations. cons - individual evaluation of the results could embed individual bias.

Table 2. Continued...

AR Step	Case 1 Description	Case 2 Description	Opportunities for remote collaboration
Monitoring (Meta-step)	The Monitoring meta-step was performed by the academic team through all the cycles of the AR. The monitoring meta-step was crucial for continuous academic data collection and learning. Consequently, the academic team was not only concerned with how the project is unfolding but also monitored the learning process and inquired into the inquiry. For that purpose, the academic team focused not only on listening to what the organisation's team reported but also observing what was in fact happening.	The Monitoring meta-step was performed by the academic team through all the cycles of the AR, which allows identifying theoretical aspects and suggesting new AR cycles to the glass company.	**Virtual Whiteboard:** pros - allowed the quick capture and sharing of perceptions, ideas and insights avoiding loss of information and knowledge sharing. Con - if used alone can lose the opportunity for co-creation and collective reflection *. **Web meetings:** Pro - allows synchronous discussions and reflections about the learning process and inquiring into the inquiry. cons - Some valuable information that only can be collected during unplanned informal activities, such as coffee breaks, talks and lunchtime would not be collected if web meetings were used. * Web meetings can be used as a good complementary tool for the use of Virtual Whiteboards for co-creation and collective reflection process.

may be supported by RCT (i.e., web meetings, and virtual whiteboards). Through group collaboration, action researchers engage with a subject position that identifies them as simultaneously researcher and organisation's team member (Blake, 2007).

According to Monk & Gehart (2003), the acceptance of the researcher into the group is fundamental to getting the most out of the research subject. It requires not only researcher reflexivity but researcher's engagement with the subject of study, including a recognition that the researcher and his/her social milieu impact the subject of study and its findings. Considering this importance, the AR academic team shall take into consideration that when choosing RCT, special attention should be put on AR team building and engagement. This characteristic of AR contrasts with the traditional scientific emphasis on objectivity through the social distance between the researcher and research subjects. Another divergence from the scientific method related to AR is the way the research problem is defined by the participation of action researchers. As action researchers not only engage with problems as they arise out of the field, but they also shift the source of the research problem from individual identity categories to social relations and institutions (Blake, 2007).

4. Findings

When conducting an AR, it is expected engagement of the academic team with the organisation's team to mutually identify a problem and its sources, and then negotiate contextualised solutions. As the COVID-19 pandemic caused mobility and meeting restrictions and consequently interruptions of some AR research activities it was evidenced the need for detailed information regarding possibilities for continuity of AR in the event of mobility or meeting restrictions. Hence, RCT was identified as a solution to minimise the restrictions to mobility and face-to-face activities. Considering that most people were not ready and eager to use RCT, this paper brings up to light the possibilities, impacts and necessities of the use of RCT as a solution for the restrictions on face-to-face activities and a possibility for the continuity and enhancement of AR activities. Considering the Covid-19 pandemic not as an "interference" on a linear trajectory, but rather as a turning point concerning the adoption of new practices, resulting in considerable and long-lasting shifts in researchers' and practitioners' perceptions. Additionally, even with the ease of restrictions, the lessons learned can be used to allow the research community to be prepared to deal with the new research, mobility or interaction challenges and an opportunity to be more efficient in conducting AR activities such as interviews, data collection, discussion and analysis.

When it comes to the use of RCT, the acceptance of the researcher into the group requires not only researcher reflexivity but the researcher's engagement with the subject of study, including a recognition that the researcher and its social milieu impact the subject of study and its findings. Consequently, special efforts should be put into team building and engagement when choosing RCT. Additionally, should also be considered how action researchers using RCT shall engage with problems as they arise out of the field, and how they shift the source of the research problem from individual identity categories to social relations and institutions. Additionally, it is important to know and consider the pros and cons that could arise from the use of the RCT. The description of the RCTs' pros and cons provided in this study provides guidance to allow managers and the academic community to know the impacts and increase AR value whilst considering fundamental quality criteria.

4.1. Practical and theoretical implications

During the COVID-19 pandemic, the authors of this paper identified that they and other researchers were facing difficulties to perform AR activities due to mobility or meeting restrictions. Hence, they identified that although there are frameworks describing the AR cycle, there is a lack of more detailed information regarding how RCT can allow possibilities for the continuity of AR in the event of mobility or meeting restrictions. To address this lack of information, the present paper presents the ex-post analysis of two face-to-face ARs, conducted by the authors. Then, the two AR cases were described in Table 2, correlated with the AR cycle steps according to Coughlan & Coghlan (2002). Additionally, it presented the pros and cons that could arise from the use of the RCT for each step of Coughlan & Coghlan´s (2002) AR cycle. The description of the RCTs' pros and cons for each step of the AR cycle offer guidance and problem-solving to support AR practising managers and the academic community to increase value considering fundamental AR quality criteria. Furthermore, it provides information on the positive and negative impacts of the use of RCT to allow AR practitioners to better planning and assuring matching AR quality criteria. Moreover, the information regarding the RCT and its pros and cons can also be used:

- to allow continuity of AR in the event of mobility or meeting restrictions;
- as an opportunity for new possibilities of research observation and interaction; and
- To improve efficiency in the use of resources.

With these contributions, we intend to provide material for the advance of the field of Operations Management, theoretically and practically.

4.2. Future research

The ex-post analysis of this study considered a sample of two AR cases, it was considered sufficient for the preliminary analysis and generation of research insights, although this sample poses a limitation as it is not sufficient to allow generalisation of the results. Hence, there is a need for the replication of this study with a bigger number of cases and with different populations or areas of applications to allow testing and generalisation of the results.

There are research opportunities to investigate the relation of AR to social, industrial and academic interests considering the agenda in new technologies implementation related to Manufacturing of the Future (EPSRC), Advanced Manufacturing Technologies (United States of America, 2018), or Industry 4.0 (SIEMENS, 2015; European Parliament, 2016). Those opportunities involve using RCT to improve the manufacture and distribution of goods and services, productivity, social welfare, income distribution and environment (Organisation for Economic Co-operation and Development, 2017). For instance, socioeconomic aspects such as the lack of skilled labour will influence the implementation of Industry 4.0 (Shamim et al., 2017) and raise concerns for emerging economies striving in a digital environment.

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