Design Research Guidelines for Mindful IT Innovations: The Case of RFID Innovation in Supply Chain Management

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Abstract

Design research is a promising research stream in the IS field, yet research output has been limited. Studies argue that this is due to the complexity of the design research methodology and that design research rarely incorporates the firm context into the design. We propose to include mindful IT innovation process into design research. The IT innovation process is a simple and easy to understand process model of IT innovation. Mindfulness on the other hand ensures that the design outcome resists IT trends, aligns IT with the firm context, fits IT with the existing system, and can ultimately lead to firm capabilities. We illustrate the proposed concept in the form of mindful design principles and instantiate the mindful design principles on a RFID innovation for a complete garment supply chain. The evaluation of the RFID innovation shows that significant benefits can be gained in an operational, tactical, and strategic sense.

1. Introduction

IS researchers often debate whether the IS field is mature enough to call itself a research stream. Numerous researchers argue that the IS field lacks core theories, which are intrinsically observed by and for the IS field [26]. Instead the IS field regularly borrows theories from other fields and apply it to IS related problems [34]. This leads to that IS research is often disconnected with real world problems. Qualitative research attempts to close the gap between practice and research, but the gap is still prevalent. IS researchers often learn by qualitatively observing existing IT innovations set forth by practitioners, rather than instigating the initial concepts for new IT innovations. Design research is introduced to the IS field to lessen the gap, by innovatively proposing new IT innovation concepts addressing real world problems.

Design research, and more specific information systems design research (ISDR), puts IT artifacts at the core of the IS discipline. ISDR aims to create a phenomenon, as opposed to natural science which aims to explain or predict a phenomenon [23]. Numerous IS journals have ushered for ISDR studies through editorials and special issues, but yet research in this area has been limited. Walls et al. [37] argue that their proposed design theory is perhaps too complex and lacks a clear guidance for other researchers to follow. Ivari [17] and Carlsson et al. [6], on the other hand, argue that ISDR still cannot close the gap between research and practice, since ISDR often neglect to take the firm context and social aspects into account. This leads to developing IT artifacts, which do not always address real world problems. As a result, ISDR is often not well recognized and often fails to contribute the cumulative IS knowledge to form core IS theories [12].

This study attempts to contribute to ISDR by proposing a parsimonious methodology for mindful designing IT artifacts in the firm context. A set of mindful design principles are proposed toward mindful IT artifacts design, followed by a case to demonstrate the proposed mindful design principles for RFID innovations in supply chain management. By incorporating mindful logic in design principles, the design artifact is customizable to the firm context by design and will more likely result into firm capabilities.

2. Literature review

2.1. Information system design research

IS research often focuses on understanding certain IS phenomena or how users interact with IT artifacts. These phenomena are often explained with natural and behavioral research [30]. A nascent stream of research, ISDR, takes on another approach and focuses on developing functional and goal-oriented IT artifacts to reach certain business objectives.

Simon [33] discusses the need for recognizing design of the artificial as a form of science. Many other scholars support his view and advocate for the need of
ISDR in the IS field [13] and [36]. The essence of ISDR aspires scholars to rigorously solve a class of real-world problems with the goal to further enrich the cumulative IS knowledge. Albeit the ISDR concept has been well received by many scholars, the number of research output has still been limited [3]. Main reasons for the limited number of ISDR studies are that ISDR is often found too difficult to apply [37] and that ISDR is often failing to address the actual practitioners’ problem [17] and [9].

Mindfulness is a state, which discusses the vigilance upon acting. For individuals it is a cognitive ability [19] and for firms it is the outcome from collective minds of the involved participants [38] and [5]. Firms in a mindful state make justified decisions, as they are vigilant and consider numerous factors while making decisions. Firms in a mindless state on the other hand tend to make decisions without a well-thought process and careful evaluation. Albeit various studies have discussed that being mindful is crucial to developing capabilities and leading to success [5], many firms still act mindless. Various factors have been identified that can lead to mindless behavior, e.g. social or external pressure and the vast resources required for carefully evaluating decisions. However, mindless behavior is not necessarily an end product, it can happen throughout the IT innovation process, which consists of comprehension, adoption, implementation, and assimilation (see Figure 1).

The comprehension process in IT innovation is a process where firms explore new technologies. In this phase the firm tries to absorb new information and is not subjected to any mindful/mindless decisions [20].

In the adoption process firms need to decide whether they will adopt a certain technology or not. Institutional pressure can lead to situations that firms do not always stay mindful. Bandwagon effect is a form of coercive pressure that often forces company to mindlessly adopt a trend in order to stay competitive [2], but it often lead to less than desirable results [8]. Mindful decisions on the other hand can resist the coercive pressure and lead to relatively more desirable results [39].

In the implementation process mindfulness leads to decisions grounded in their own firms’ facts and specifics. In other words, mindfulness in this process ensures that technologies fit the firms’ goal. Numerous studies discuss that mindlessly misaligning IT with firm strategies often lead to disappointing results or

### Figure 1. Mindful IT innovation process [20]

Peppers et al. [28] are one of the few to propose a comprehensive methodology for ISDR. They argue that the lack of a commonly accepted methodology for ISDR may be the reason for the limited research output. The paper follows an engineering line of thought, where they believe that design can be codified [4]. They therefore articulated sequential processes towards an ISDR methodology, which include: problem identification and motivation, definition of the objectives for a solution, design and development, demonstration, evaluation, and communication.

Sein et al. [32], on the other hand, argues that ISDR might not be as sequential like stage-gate models [7]. They argue that stage-gate models separate and disconnect building from evaluating. As a result the final IT artifact may not rightfully serve the users. Action design research is proposed for “generating prescriptive design knowledge through building and evaluating ensemble IT artifacts in an organizational setting” [32]. Carlsson et al. [6] share a similar view where they do not only consider the IT artifact, but also consider the socio-technical aspect in ISDR. Thus they argue that the design needs to be continuously revised through evaluating the design with the users. This ensures that the design indeed address the problem in the actual firm context.

#### 2.2. Mindfulness in IT innovation
even IT failures and while IT business alignment can lead to capabilities and competitive advantages [35].

In the assimilation process mindful decisions need to blend IT with the firms’ worklife. After all, IT capabilities are often formed in conjunction with other capabilities [21]. When firms act mindless and do not blend in the IT innovation with the worklife, it will most likely cause resistance from the users and can capsize IT projects, while mindful assimilations can compliment and strengthen firm competencies [18].

3. ISDR towards mindful IT innovation

Prior studies made great strides for ISDR by applying and extending ISDR in the IS field to further close the gap between research and practice. However, literature discusses that a gap between research and practice is still prevalent. Action design research can indeed bring in the firm context in the design, but that would mean that each design needs to be revised given the firm specific context. This is undoubtedly a laborious undertaking and requires expertise from the original designers. We therefore propose that the original design should take customization into consideration [15]. As a matter of fact, this study proposes to include the mindful IT innovation processes into the design. Design process occurs after the adoption process, while the IT artifact is created after the implementation and is fine tuned in the assimilation process. A good IT artifact design is one thing, but comprehension, adoption, implementation and assimilation are equally important. IT projects are destined to fail if the IT artifact is not well comprehended, adopted, implemented or assimilated, albeit it may have a top notch design.

This study therefore proposes an ISDR towards mindful IT innovations. Our methodology will propose a set of parsimonious guidelines by taking the IT innovation processes into consideration. After all, IT innovation processes are recognizable and easy to grasp for both academics and practitioners. The mindful design guideline ensures that the design process stays mindful throughout the IT innovation processes. The mindful approach in IT innovation provides a better chance of developing firm capabilities and ultimately leads to competitive advantages. Prior studies on ISDR focus on a whole class of problems [11], [24], and [1], but seldom investigate whether the IT artifact fit the firm context and can enrich the firm competences. Therefore our meta-requirement is to develop a parsimonious mindful design to fit the firm context and can enrich the firm competences.

The adoption, implementation, and assimilation processes are all subjected by mindful decisions in the IT innovation process. Mindfulness in these three processes can greatly improve the chance of developing firm capabilities [20]. The comprehension process in IT innovation is the first step to get acquainted with the new technology and is not subjected to either mindfulness or mindlessness (see Figure 2). At this process the firm needs to get a good understanding of what the technology can and cannot do. Conversely, firms need to decide whether to adopt a certain technology or not in the adoption process. They need to be mindful in the adoption process and be wary not to mindlessly use existing IT artifacts or mimic competitors and investigate what they intend to achieve with the technology. Mindlessness in the adoption process can jeopardize the further IT innovation processes and lead to project failure [29]. In the implementation process firms need to mindfully ensure that the technology fits the firm’s business needs. Thus merely solving a class of problem is inadequate, as not all firms face similar macro problem [27]. Notice that a mindless decision in the adoption process will increase the likelihood of mindless decisions in the implementation process. In the assimilation process firms need to mindlessly assure that the design takes the existing system and worklife into consideration, as resistance or improper assimilation can endanger the mindful design in the prior IT innovation processes. As a result the mindful ISDR should satisfy the following propositions:

![Figure 2. Proposed guidelines for design research towards mindful IT innovation](image-url)
**Figure 3. The garment supply chain**

**Proposition 1:** mindful ISDR prevents mindlessly jumping on the bandwagon

**Proposition 2:** mindful ISDR safeguards the IT innovation to fit the firm context

**Proposition 3:** mindful ISDR enforces the IT innovation to blend in the existing system

Albeit the IT innovation seems like a sequential process, refinements and iterations are inevitable. For instance, incompatibilities discovered in the assimilation process can lead to refinements to the prior processes. Therefore, mindful design guidelines may occur interchangeably or even concurrent, as is proposed by action design research.

Another goal of the proposed mindful design guidelines is to embed customization in the design. It would therefore be beneficial to propose agile design for the IT innovation processes. Agile design favors the processes to be adaptive rather than iterative like the mindful design guidelines and ensure that the design is flexible for changes. We advocate for an agile design approach, as this approach allows the design to easily customize the IT artifact to the firm context by design. For more readings on agile design the readers are referred to [25] and [14].

4. Instantiating the proposed mindful design guidelines

4.1. Garment supply chain case

We illustrate the proposed mindful design guidelines by an RFID innovation in a garment supply chain. The supply chain in question handles high-end men’s fashion wear. The partners in the supply chain include fabrics and trims suppliers, fabrics warehouse, parts supplier, garments factory, garments warehouse and retail shops (see Figure 3). In this garment supply chain the brand owner sources all the fabrics and trims to ensure a high quality standard. The suppliers are usually located in Europe and South-east Asia. All fabrics and trims are first received in the brand owner’s fabrics warehouse, which is located in Hong Kong.

Subsequently, the fabrics warehouse ships the fabrics and trims to parts supplier located in Shenzhen, where the fabrics and trims are crafted into parts. Once finished, the Shenzhen parts supplier ships out the parts to Hong Kong where the parts are assembled together in the garments factory, also owned by the brand owner, to form the final garment. However, in some cases final touch-ups are required, which are done by the Shenzhen parts supplier. Besides, not all garments are produced in-house and some products are sourced from third parties, who are mostly located in China, again the fabrics and trims are sourced by the brand owner in order to ensure the high quality standards. The finished garments are all stored in the garments warehouse, located in Hong Kong, where it awaits to be shipped out to retail stores around the world.

The supply chain shows that a close relationship between supply chain partners is required for a smooth supply chain operation. The brand owner can be seen as the orchestrator of the supply chain. Information sharing is mainly one-sided where the brand owner places orders at the supply chain partners. The order placing is usually done per fax and email. The supply chain partners must where possible adjust their planning to the brand owners plan. However, supply chain partners cannot always meet the brand owner’s plan, which causes delay in production and can lead to lost sales at the retail shops. The brand owner, therefore, must keep a high inventory in the garments warehouse to satisfy the volatile demand of the fashion industry. The brand owner typically plans one year ahead, due to the long lead-time. The long lead-time and the high dependency of the supply chain partners cause the supply chain to be highly inflexible. The garment supply chain therefore wants RFID to improve their flexibility by compressing the lead-time and to enhance the supply chain partners’ collaboration by enhancing supply chain visibility (SCV). The supply chain characteristics and issues we encountered in this supply chain are not uncommon to other garment supply chain and are as a matter they are commonly found in other types of supply chains as well.

4.2. Mindful design principles for RFID in SCM
In this section we share our experiences for innovating with RFID in the garment supply chain by articulating mindful design principles according to our mindful design guidelines, see Figure 4. These mindful design principles are developed based on our garment supply chain requirements. It serves as a demonstration to illustrate how design science can be mindfully used in conjunction with the IT innovation processes to develop a highly customizable IT artifact by design.

**Mindful design principle: Align RFID expectations through understanding RFID landscape**

In the comprehension process we first investigated the RFID technology landscape with the supply chain parties. Several sessions were organized to gain a consensus on what RFID can and cannot achieve. The sessions showed that some supply chain partners did not have interest in the technology from the start, whilst others thought RFID was the silver bullet to solve their supply chain problems. We therefore discussed several cases of RFID innovations in supply chain management to gain a better understanding and leveled the expectation of RFID among all supply chain partners. Early involvement of the users can better address the socio-technical aspect by providing a better understanding of the supply chain problem and by lowering the resistance of the users.

**Mindful design principle: Define the RFID objectives through SCOR defined KPIs**

The following sessions identified what the users wanted to achieve with RFID. The most prominent problem in the supply chain was the long lead-time. We used SCOR (Supply Chain Operations Reference) model as a basis to identify KPIs that we need to address with RFID. SCOR is a widely accepted model to measure supply chain performance and also serves as a common language among practitioners to discuss supply chain issues [22]. We quickly identified responsiveness as the key KPI that we needed to address in this project, since the lead-times were heavily fluctuating (see Figure 5). Notice that Figure 5 only shows the level one performance metrics and the performance metrics can actually be further decomposed into a more detailed level two and three.

**Mindful design principle: Derive SCV from transactional data and operational data**

RFID is expected to improve the supply chain responsiveness by automating many labor intensive processes. Furthermore, RFID is also expected to improve the SCV, in order to facilitate smooth supply chain cooperation. A quick review on the existing RFID systems showed that the existing systems did not make good use of the RFID data and often treated them separately from existing data. We therefore decided that it would be best to develop our own RFID system, rather than using or customizing existing ones. The RFID system should combine the transactional data, e.g. ERP, with the operational data, e.g. RFID. We designed a meta-information agent, which could interface with the RFID readers and the existing systems through XML.

**Mindful design principle: Deploy RFID hotspots through KPI driven RFID framework**

We used SCOR to analyze which business processes are most suitable to RFID-enable. SCOR has the advantage that it links business processes with KPIs [31]. Thus SCOR can identify which business processes affect certain KPIs and in our case the responsiveness KPI. We carefully examined each business process that affect the responsiveness KPI and propose a way to re-engineer the respective business
processes. Re-engineering is based on how RFID can reduce lead time and what RFID data to capture for forming SCV. As a result we RFID-enabled 5 business processes (hotspots) for the fabrics warehouse, namely receive materials, verify materials, stage materials, pick & pack materials, and ship materials. Furthermore, we developed 7 hotspots for parts supplier, 4 hotspots for garments factory, 4 hotspots for garments warehouse, and 4 hotspots for retail shop. Note that all 24 hotspots improve the responsiveness KPI and contribute to SCV (see Figure 5).

*Mindful design principle: Provision on-target SCV through vTemplates*

Obviously, the meta-information agent has abundant of supply chain information. However, both literature and practitioners lack methods to represent it in a usable way to the users. We therefore first asked the users on what supply chain information they would like to obtain. However, none of the users were able to clearly identify what information they desired. A further investigation in the literature resulted with no clear answer either. Most studies advocate that more information is better [10] or are focused on a specific part of the supply chain, e.g. POS [16]. We therefore took another approach, by rather defining the users’ SCV we postponed it and allowed the user to define their own (on-target) SCV. A screenshot of the personalized on-target SCV can be found in Figure 6. The screen shot shows that all the RFID and system data can be found on the left pane, the user can create their SCV by simply dragging and dropping their desired data to the right pane and form a “vTemplate”. The actual viewing of a vTemplate is shown in Figure 7. The Figure shows the real-time RFID updates highlighted in yellow, in this case the fabrics warehouse just shipped out the materials.

*Mindful design principle: Engage supply chain partners by pre-defining vTemplates*

In order to lower the user resistance we tried to define several pre-defined vTemplates with various users. We purposely engaged users to define their supply chain partners’ SCV. Since the upstream and downstream partners are more aware on what information they have on hand and can share with others. This way the users can familiarize with vTemplates and this exercise can help them better understand what sort of supply chain information is available. For instance, we developed a material management vTemplate with the Fabrics warehouse and brand owner, which allows the brand owner to clearly track where the fabrics are located at any given moment. This is important for the brand owner, since fabrics constitute to half of the total production cost. Similarly, we also developed a vTemplate for the garments factory with the fabrics warehouse, parts supplier, and garments factory, to monitor the progress of the parts supplier. This allows the garments factory
to better follow the production schedule or alter it when disruptions at the parts supplier are foreseen.

Mindful design principle: Provide an on-demand SCV platform with plug and sync functionality

The garment supply chain, and supply chains in general, are characterized by firms of various sizes. RFID investments can especially be taxing on small firms. We therefore developed a SCV platform in such a way that it requires minimum investments for the small firms. The SCV platform is provided through the Internet and users therefore do not need to invest in any RFID systems, other than RFID readers. Basically, users can access SCV through any device with a browser and an Internet connection. This way users can access SCV (on-demand) anywhere and anytime as a simple service rather than a piece of software, which they need to buy, install, configure, and maintain. Besides, garment supply chains are also characterized that partners can change. This implies that the SCV platform must facilitate an easy access and exit (plug and sync). The plug and sync module allows a user to log in the SCV platform and it can automatically synchronize the relevant SCV information through an XML specified interface. Obviously, access control is enforced and prevents users from accessing information outside their supply chain.

Mindful design principle: Evaluate and improve RFID hotspot design through a real-time dashboard

The platform is designed in such a way that it can provide a real-time dashboard view of the current supply chain performance. Thus albeit the RFID innovation focuses on responsiveness KPI, it will also monitor other available KPIs. This allows supply chain partners to easily detect supply chain disruptions. Besides, the platform provides real-time feedback to the re-engineered business processes. This way further refinements or changes can be made to the business processes and the performance impact will be directly visible on the dashboard.

5. Evaluation of the mindful design principles

The mindful design principles are articulated in such a way to specifically address the three
propositions. The first proposition: *mindful ISDR prevents mindlessly jumping on the bandwagon* is addressed by the mindful design principles in the adoption process. These mindful design principles require to investigate the firm’s goals and to determine how the IT innovation can help the firm, rather than just simply by considering off-the-shelf solutions. The mindful design principles in the implementation process, on the other hand, address the second proposition: *mindful ISDR safeguards the IT innovation to fit the firm context*. These mindful design principles warrant that the IT innovation does not stray from the goals (responsiveness KPI) set in the adoption process through the SCOR model. Finally, the third proposition: *mindful ISDR enforces the IT innovation to blend in the existing system* is addressed by the mindful design principles in the assimilation process. These mindful design principles are designed to carefully synergize the IT innovation with the existing system through a platform and to further enhance the IT innovation.

We further evaluate our mindful design principles by the improvements found in the KPI, as we cannot compare it to other artifacts since this is one of the first artifact to address a complete supply chain. The project has delivered the supply chain with various operational benefits to improve its supply chain efficiency and reduce the time-to-market. Most of the operational benefits can be found in receiving and stock taking products. For instance, the fabrics warehouse only has the capacity to receive 50 rolls per day without RFID, whilst with RFID they can receive all 100 rolls during peak seasons. Moreover, the fabrics warehouse does not have adequate manpower to perform a stock take without RFID, whilst with RFID they can perform a full stock take in less than 10 minutes. Similar operational benefits can be found for other supply chain partners, as shown in Table 1.

In addition the RFID innovation provides the users with a more transparent supply chain, which allows them to quickly identify supply chain deficiencies and gain tactical benefits by eliminating the aforementioned supply chain issues:

- **Material management** – The RFID innovation allows both the fabrics warehouse and the parts supplier to exactly know where the materials are located. Besides it allows the parts supplier to know whether the fabrics are in place before the production actually starts. This information was unavailable before using RFID, causing many production delays.

- **Production management** – The garments factory can now identify production delays at an early stage, as we strategically placed RFID readers at designated workstations. This allows the garments factory to closely monitor the work in progress at the external parts supplier and adjust the production planning accordingly.

- **Distribution management** – The garments warehouse can now view the number of garments at the garments factory’s final workstation, which indicates that the garments will arrive at the garments warehouse in a week. This helps the garments warehouse to better plan their warehouse allocation management. Furthermore, the garments warehouse can also view the inventory level at the retailers, which allows them to better anticipate the customer demand and reduce the safety stock.

- **Supply chain management** – RFID offers real-time supply chain performance measurements based on SCOR metrics. This provides the supply chain with a real-time dashboard of the supply chain performance and supply chain glitches can be detected at an early stage before undesirable effects propagate. This ensures that the operation follows the supply chain plan and reduces the chance of out-of-stock situations, which can help to satisfy the customer demand.

We foresee that the garment supply chain can become more agile with the RFID solution, since the

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<tr>
<th>SC party</th>
<th>Operational benefits</th>
<th>Tactical benefits</th>
</tr>
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<tbody>
<tr>
<td>Fabrics WH</td>
<td>Double capacity</td>
<td>Manage materials over two sites</td>
</tr>
<tr>
<td>Parts supplier</td>
<td>Verify vs. count</td>
<td>Ensure material availability per PO</td>
</tr>
<tr>
<td>Garments Fact.</td>
<td>Save 94% time</td>
<td>Monitor parts supplier progress</td>
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<tr>
<td>Garments WH</td>
<td>Save 83% time</td>
<td>Enable more advanced WH planning</td>
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<tr>
<td>Retailer</td>
<td>Verify vs. count</td>
<td>Prevent out-of-stock situations</td>
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Strategic Benefits can be developed from SC visibility and change the supply chain configuration from Make-to-stock → Make-to-order

Table 1. RFID-enabled garment supply chain benefits
order fulfillment cycle time has compressed and the perfect order fulfillment has improved. This ushered the brand owner to consider changing its current make-to-stock strategy to an eventual make-to-order strategy.

We can also observe that the RFID innovation does not tax the supply chains’ systems. After all, RFID requires a lot of data processing and all the data processing is performed at the platform. This also lowers the barrier of RFID adoption, as no additional resources are required.

6. Discussion

This study proposed a methodology, in the form of mindful design guidelines, for mindful ISDR with the IT innovation processes in mind. The IT innovation process is identifiable and easy to understand by both practitioners and academics. Furthermore, the mindfulness in the design ensures that firm context is taken into account and subsequently has a better chance to result into firm capabilities. The mindful design guidelines ensure that the design will not be subjected to the mindlessness effects in IT innovation, namely bandwagon effect, IT misalignment effect, and adaptation effect. We illustrate the mindful design guidelines instantiating it for a garment supply chain. As a result, we propose a set of mindful design principles, which are designed in such a way that the desired KPI will determine which business processes to RFID enable. Subsequently the captured RFID data is integrated with the existing system data via a platform to provide a personalized visibility, vTemplate, to the users. vTemplates allows the users to define their own SCV rather than predefining it for them. The KPI improvements demonstrated the effectiveness of the design.

The garment supply chain was mainly located in Asia and the Asian context may affect the findings. However, we often deal with global supply chains and upstream supply chains are still often located in Asia. Therefore the findings should nevertheless be valid for the upstream supply chain. This project also dealt with RFID, which is still a novel technology and is expected to have a big impact on the supply chains. Older technology and less radical technologies may alter the findings. The mindful design principles are currently only applied in one garment supply chain and generalization should be made with care.

However, we intend to implement our mindful design principles towards mindful IT innovation in other supply chains and this should improve the generalizability of our findings. Future studies could also investigate in other sectors. Albeit SCOR should be applicable to all kinds of supply chains, minor modifications may be needed. The concept of KPI driven design principles should remain valid in the supply chain context. However, when the mindful design principles are used in contexts other than supply chains, then another model than SCOR should be utilized. Used. However, the mindful design guidelines are developed without a specific technology in mind and should be applicable to other technologies. Nevertheless, future studies are encouraged apply the mindful design guidelines to other technologies to test the generalizability of the design.

7. References


