

Concept Paper

Implementation of Digital Technologies in Construction Companies: Establishing a Holistic Process which Addresses Current Barriers

Peter Schnell *, Phillip Haag  and Hans Christian Jünger

Department of Construction Management, University of Stuttgart, Pfaffenwaldring 7, 70569 Stuttgart, Germany

* Correspondence: peter.schnell@zech-hochbau.de; Tel.: +49-173-348-2337

Abstract: Digital technologies are being introduced in all areas of the construction industry with the overarching goals of increasing productivity while simultaneously simplifying work and reducing errors. Nevertheless, their use and the associated implementation in construction companies is currently still inhibited. One reason for this is the lack of a holistic implementation process for digital technologies. Therefore, the aim of this paper is to deliver a concept for such a holistic digital-technology-implementation-process which addresses current barriers. For this purpose, a qualitative literature analysis was conducted first, which reveals the current focus of research on digital technologies. In a second step, current barriers regarding the implementation of digital technologies were identified by conducting interviews with experts from German construction companies. The interview concept combined and adapted the survey instruments *Technology Commitment* by Neyer et al. and *Technophobia* by Sinkovics. Based on the findings of the qualitative literature research and the expert interviews, a holistic implementation process for the introduction of digital technologies for construction companies was developed, which specifically addresses the currently prevailing barriers. Therefore, the barriers *Acceptance*, *Control* and *Competence* were classified in a temporal context within the implementation process and recommendations for action are presented for the individual process steps of implementing digital technologies.

Keywords: digital technologies; construction industry; barriers; implementation process; literature review; expert interviews



Citation: Schnell, P.; Haag, P.; Jünger, H.C. Implementation of Digital Technologies in Construction Companies: Establishing a Holistic Process which Addresses Current Barriers. *Businesses* **2023**, *3*, 1–18. <https://doi.org/10.3390/businesses3010001>

Received: 9 December 2022

Revised: 22 December 2022

Accepted: 23 December 2022

Published: 27 December 2022



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Digitalization is increasingly finding its way into all sectors of the economy. In the construction industry, digital tools are in fact available for various applications along the building life cycle and value chain today [1]. The diversity of the construction industry offers a variety of digital tools for various applications in all phases of the life cycle and during the construction of structures and buildings and aims to improve economic or environmental benefits [2,3]. However, when comparing different industries in terms of the progress of digitalization, the construction industry is ranked comparatively low, as for example the digitalization index of Telekom [4] or a survey by McKinsey [5] demonstrates. Here, construction remains far behind industries such as the automotive or finance industries. While these analyses regarding the degree of digitalization show the current status as the result of an overall economic survey, a determination of the background, i.e., an analysis of the causes, is not part of the research studies.

When planning to integrate (new) digital technologies, it is essential that possible barriers are known so that the introduction can take place as efficiently and successfully as possible [2,6]. Currently, there is a lack of standardized processes that could be used for the introduction of digital technologies. This is in accordance with Jin et al. [7], who postulate that implementation processes need to be further researched and investigated as

a key finding in their review on BIM technology. This leads to the following three research questions, which need to be addressed:

- Research Question 1:

What is the status quo of implementation processes for digital technologies and which barriers are currently highlighted in research?

- Research Question 2:

What are the current barriers for implementing digital tools in the construction industry?

- Research Question 3:

How can digital tools be introduced in the future as a holistically optimized process?

To answer Research Question 1, a qualitative literature review was carried out, first to identify the status quo of standardized implementation processes of digital technologies within the construction industry, as well as current barriers associated with this process. Thereby, the relevant literature was identified and utilized for an in-depth analysis.

In order to determine the reasons why the level of digitalization among construction companies is currently still low, expert interviews were conducted with 15 German construction companies in a second step (Research Question 2). The survey refers to the largest construction companies, as these represent a significant proportion of employees due to their size and are simultaneously able to overcome monetary obstacles more easily. Nevertheless, in terms of sociotechnical barriers, these companies also provide insights that are directly transferable to companies of other sizes. The aim of the survey is to provide an overview of the current attitude of construction companies towards digital technologies and thus to uncover the prevailing barriers to their implementation and use.

Lastly, the two steps were combined into a standardized implementation process that addresses the identified barriers (Research Question 3).

On the one hand, the result should help construction companies to integrate current digital technologies more efficiently and to be able to respond to specific needs. On the other hand, it should serve as a starting point for successful implementations of digital technologies in the future by including thoughts on common barriers beforehand, thus accelerating the digitalization of the industry.

In this paper digital technologies are defined as hardware and software, which are used to support, improve, or complement existing technologies. This can include the digitalization of a process, such as the accounting control, or the use of a new digital product on site such as drones, among others.

2. Qualitative Literature Review to Answer Research Question 1

In order to answer Research Question 1, a standardized literature review was conducted according to Hu et al. [8] based on the PRISMA principles and methods [9]. These systematic reviews are a substantial part of research due to the examination of the current status quo regarding relevant literature in the scientific field [10]. Furthermore, upcoming trends, research gaps and current research challenges can be identified and discussed [11].

For the following literature review, two databases served as a source for a material retrieval, as shown in Figure 1. Afterwards, the literature was selected, presented via a literature overview and qualitatively reviewed.

2.1. Material Retrieval

The objectives of the retrieval were primary literature sources, such as research articles published in academic journals or conference proceedings. By utilizing the databases *Web of Science* and *Scopus* and searching for keywords alone and in combination, literature for a qualitative literature analysis was acquired in the first step. The search keywords (*digital technologies, construction industry, obstacles/difficulties/barrier, and implementation process*) were selected to address the research question.

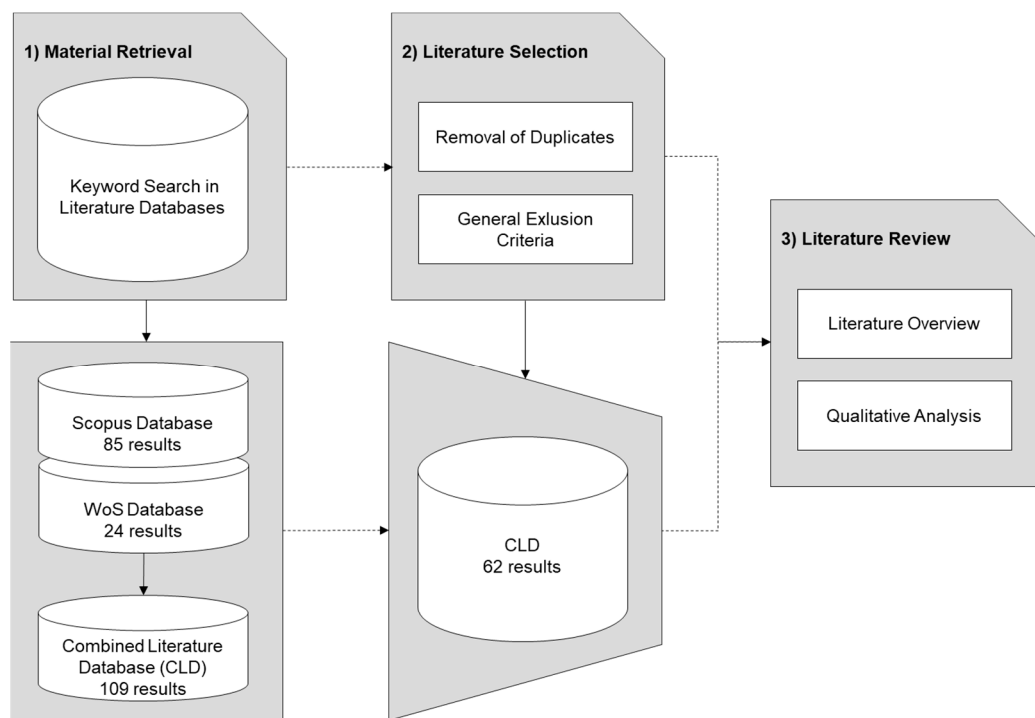


Figure 1. Systematic literature review process.

All papers between the years 2000 and 2022 were included in the retrieval process. Due to the fact that a niche topic was being investigated, the search conditions in the databases were extended to searching within the title, abstract and keywords of the papers to ensure that all relevant sources regarding the research topic were obtained. Table 1 lists the detailed logical statements, the search strings and the number of papers from each database.

Table 1. The logical statement, the corresponding search strings and the results from the databases Web of Science and Scopus (date of extraction: 10 February 2022).

No.	Logical Statement	Search String	Results "Web of Science"	Results "Scopus"	Total
1	Barriers regarding digital technologies in the construction industry.	=("DIGITAL TECHNOLOGIES" AND "CONSTRUCTION INDUSTRY" AND ("BARRIERS" OR "OBSTACLES" OR "DIFFICULTIES"))	6	18	24
2	Implementation process of digital technologies in construction industry	=("DIGITAL TECHNOLOGIES" AND "CONSTRUCTION INDUSTRY" AND ("IMPLEMENTATION" OR "IMPLEMENTATION PROCESS"))	14	57	71
3	Barriers regarding the implementation process of digital technologies in the construction industry.	=("DIGITAL TECHNOLOGIES" AND "CONSTRUCTION INDUSTRY" AND ("IMPLEMENTATION PROCESS" OR "IMPLEMENTATION") AND ("BARRIERS" OR "OBSTACLES" OR "DIFFICULTIES"))	4	10	14
Total			24	85	109

In total, 109 literature sources from all search strings were individually collected and combined into a single combined literature database (CLD) by importing the results into

the Zotero reference management software as a .ris file. The CLD included the relevant information regarding, e.g., the authors, the paper and the corresponding journal.

2.2. Literature Selection

The literature resulting from the material retrieval needed to be further selected in order to comply with the credibility of a standardized literature review [11,12]. To avoid duplicates, literature findings with matching information were first combined with the Zotero software. This process reduced the literature base to 73 papers. Especially the search range in keywords, abstract and title implied that the selection process needed to be more strictly specified. Therefore, exclusion criteria as introduced by Salim et al. and Vilela et al. [13,14] were adopted and complemented. Thereby, all literature that fit in the following six categories were excluded from the qualitative review:

1. Less than five pages.
2. Grey literature.
3. Languages other than English.
4. Non-peer-reviewed journals.
5. Articles that do not directly relate to the stated keywords.
6. Lack of information about the authors etc. or the full text.

After applying the exclusion criteria, 62 literature sources were left to run the literature overview and the qualitative review.

2.3. Literature Overview

For the literature overview, the CLD was first visualized using a scientometric analysis. This visualization technique, based on a quantitative evaluation and mapping of scientific parameters, such as keywords or author names, enhances a rapid perception of the collected literature sources [7,8].

In this paper, a visual network of relevant keywords was created by using the open-source software VOSviewer, as suggested by other systematic literature review researchers [7,15,16]. Article keywords reflect foremost the core content of the corresponding scientific text [17]. This grants the reader a perception of the broached topics and, thereby, gives literature reviewers the chance to look at the relevance of certain scientific topics over a broad base of literature. For the visualization approach in this paper, the CLD was exported as a .ris file from the Zotero software and imported in the VOSviewer application. In addition, synonyms and similar words, such as building information modelling and bim or digital technologies and digital technology were merged via a thesaurus.txt file to form a clearer picture. Figure 2 shows all keywords from the CLD that were used more than twice in order to keep a focus on the relevant research topic. The larger the node, the more often the keywords were used in the CLD.

It becomes transparent that besides the keywords digital technologies and construction industry, the keywords obstacles and difficulties are not existent in the visualized network. Only the keyword barriers is used four times [6,18–21].

The keywords bim ($n = 23$) and architectural design ($n = 21$) stand out as the keywords used most, indicating highly researched scientific fields within this analysis. Furthermore, information theory ($n = 9$), information ($n = 7$) and information management ($n = 6$) build a frequently used group of keywords. As expected, the keywords also show a wide variety of novel technological applications and innovations, such as the internet of things ($n = 4$), artificial intelligence ($n = 2$) or 3D printers ($n = 2$) but also a trend towards sustainability with the keywords sustainable construction ($n = 2$) or green building ($n = 2$). Besides, some individual countries and cities Singapore ($n = 2$), Hong Kong ($n = 2$) or the Russian Federation ($n = 3$) are listed as keywords in the network.

When looking at the time of publication in Figure 3, the literature sources from the CLD indicate a strong trend in research during the last years. From 2016 until the end of 2021, the amount of literature published increased more than tenfold. Until 2017, research was heavily centred on building information modelling (BIM), generating primarily strate-

gically oriented papers [7,22–26], first critical reviews on BIM policy [27,28] and specific applications for the BIM technology [29,30]. This is also reflected in the top 10 cited articles from the database listed in Table 2. Furthermore, six out of ten articles and the five most cited literature sources are also BIM-related. The four articles that do not have a BIM focus either address individual technological aspects, such as collaboration technologies [31,32], or deal with strategic research questions [33,34]. The increased research over the last years could be explained by the broad range of digital technologies becoming available to the construction industry, such as the IoT [35] or blockchain [36] becoming available for the construction industry.

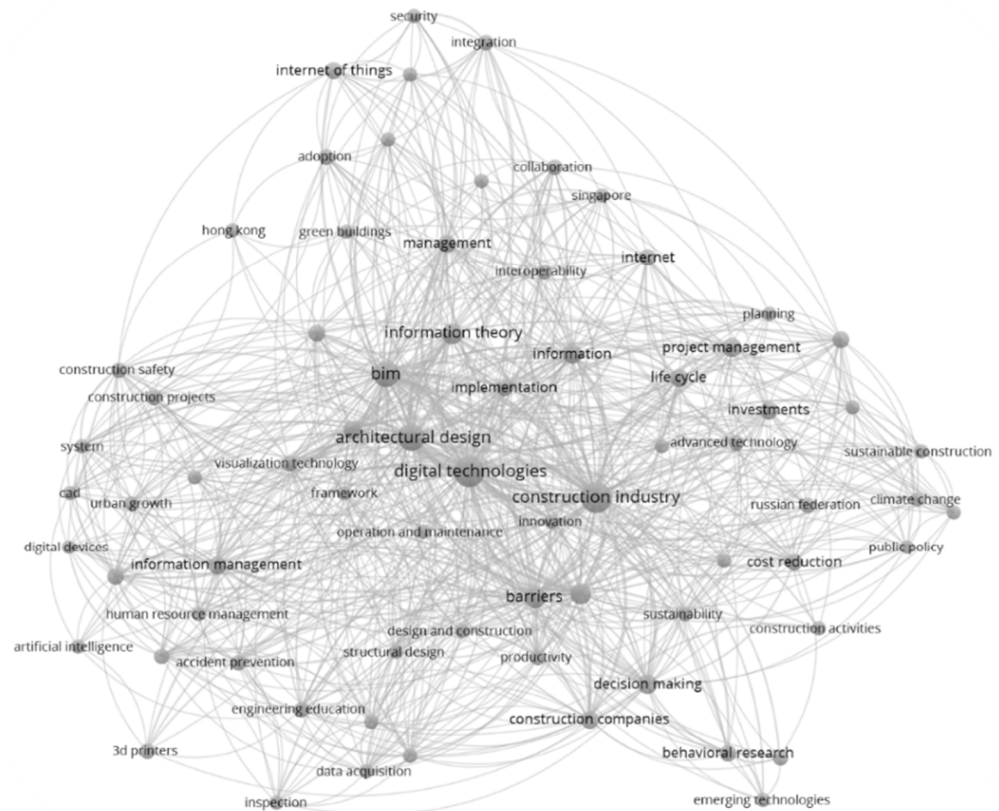


Figure 2. Scientometric keyword visualization of the combined literature database (CLD) via VOSviewer.

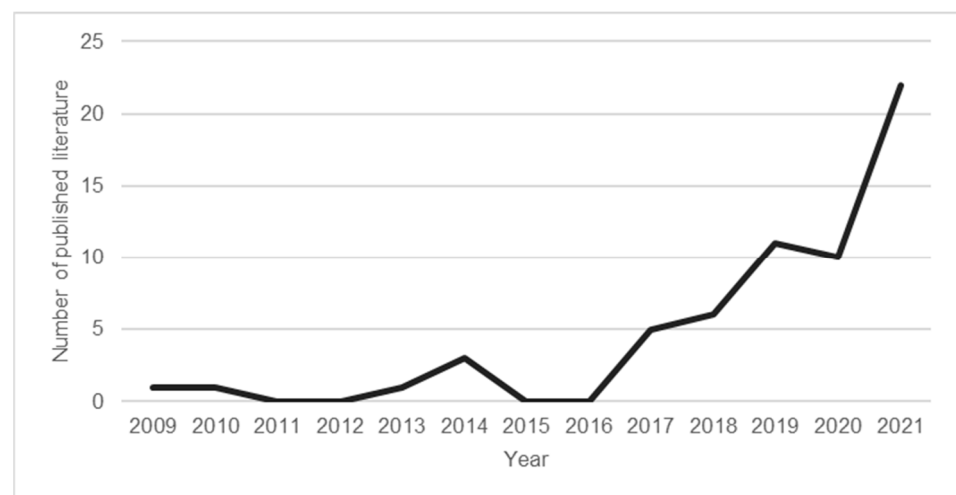


Figure 3. Publications in the CLD between 2009 and 2021.

Table 2. Top ten cited papers from the CLD.

No.	Authors	Year	Title	No. of Citations
1	Zou, Y., Kiviniemi, A., Jones, S.W.	2017	A review of risk management through BIM and BIM-related technologies	141
2	Smith, P.	2014	BIM implementation—Global strategies	125
3	Dainty, A., Leiringer, R., Ferne, S., Harty, C.	2017	BIM and the small construction firm: a critical perspective	87
4	Jin, R., Hancock, C.M., Tang, L., Wanatowski, D.	2017	BIM investment, returns, and risks in China’s AEC Industries	55
5	Hassan Ibrahim, N.	2013	Reviewing the evidence: Use of digital collaboration technologies in major building and infrastructure projects	44
6	Jin, R., Zou, Y., Gidado, K., Ashton, P., Painting, N.	2019	Scientometric analysis of BIM-based research in construction engineering and management	34
7	Lokshina, I.V., Greguš, M., Thomas, W.L.	2019	Application of integrated building information modeling, IoT and blockchain technologies in system design of a smart building	25
8	Oke, A.E., Aghimien, D.O., Aigbavboa, C.O., Koloko, N.	2018	Challenges of digital collaboration in the South African construction industry	15
9	Ghosh, A., Edwards, D.J., Hosseini, M.R., Al-Ameri, R., Abawajy, J., Thwal, W.D.	2021	Real-time structural health monitoring for concrete beams: a cost-effective ‘Industry 4.0’ solution using piezo sensors	12
10	Sepasgozar, S.M.E.	2020	Digital technology utilisation decisions for facilitating the implementation of Industry 4.0 technologies	9

2.4. Qualitative Literature Analysis

The qualitative literature analysis places the results from the literature overview in context and discusses the literature in order to answer Research Question 1. As mentioned previously, Zou et al. [28] stated the need for a general implementation process for new technologies. However, regarding the implementation of digital technology, research currently only touches on the approach to formulate and set-up a general implementation process. From the literature, three main reasons for this blind spot can be derived.

First of all, literature regarding the implementation of digital technologies in the construction industry is centred around the BIM technology, as shown in the literature overview in chapter 2.3. Smith [26] addresses implementation strategies of BIM on a global level and finds that implementation is strongly dependent on leadership on the one hand and the support of the government on the other. The positive impact of the involvement

of government in the overall implementation process of BIM and the implementation of digital technologies is also stated by Atkinson [22]. When looking at the construction company level, the benefits of implementation BIM are being paid most attention to [25]. This promotion of the BIM technology is further stressed with the potential of integrating a broad range of other digital technologies or applications into BIM, such as integrated project delivery and off-site construction [7]. Thereby, the drive to consider a BIM implementation process is looked at as an optimization for specialised fields, e.g., building energy simulations [37] or marine engineering when analysing the life cycle of offshore wind farms [38].

Next, the literature focusses on the individual technologies rather than on the implementation of digital technologies in general. Technologies for the optimization of site safety [21,39,40], blockchain-based technologies [36], virtual reality (VR) [39], collaboration technologies (Hassan Ibrahim, 2013), the internet of things (IoT) [31,35] or additive construction technologies [41] are especially favoured topics. Chen et al. [1] looked at the individual technologies at a more holistic level by categorising new implemented technologies by functionality and giving an overview of the general benefits of the respective technologies. Thereby, the researchers provide support for decision-making for construction companies by analysing which tool to choose at selected stages of construction projects.

Another key finding which might lead to the rarity of a generalized implementation process are the variety of country-based studies on digital technologies in the construction industry, e.g., to boost productivity in New Zealand [42]. It is noticeable that most of the country-specific research from the CLD is from Asia (China [24], Singapore [43,44], India [6,45] and Russia [46,47]) or Africa (Nigeria [19,48] and South Africa [33,49]). While this research provides insights for the researchers and construction industry in the corresponding countries, the viewpoint is limited towards a specific region and individual requirements. This becomes especially noticeable when considering, e.g., digital technologies for public procurement in a country [46] or comparing individual digitalization practices in construction projects between two countries [48].

Looking at the three main reasons for a blind spot in a general implementation process for digital technologies, it becomes clear from the literature of the CLD that the narrative towards a general implementation process for digital technologies needs to look at digital technologies at a more holistic level and thereby bring the findings from the individual technology or the country-specific level together. However, this process also requires an in-depth look into current barriers regarding the implementation process of digital technologies to address them in advance.

The initial decision for or against a digital technology builds a barrier on its own and is dependent on the customers [34], the phase of the construction project [1], the strategy of the individual construction company, their culture, employees and organisational management [25,50] as well as the technology itself [24,28]. Furthermore, Bajpai and Misra [6] argued that the high initial implementation cost and the long return on investment periods build financial barriers. After the initial implementation, organisational barriers arise, especially the lack of training opportunities [51] and thus low competence of the employees [18], the operational management not approaching, monitoring and controlling the use of digital implementation [6,21] and concerns about data security [19]. Lastly, current business models, strategies [18] and the lack of knowledge [20] in regards to the implementation of digital technologies is inhibiting as well, stressing the research objective of this paper and the need for a general implementation model which addresses current barriers.

To summarize, BIM, individual technologies and country-specific research is currently the focus regarding implementation processes in the construction industry. In order to scale the implementation of these technologies within the construction industry, a holistic implementation process is needed. However, this process needs to address the current barriers that are listed and discussed in research.

While barriers regarding customer requirements, organizational structure, individual employees, financial aspects and the technology itself is not an integral part of this paper,

this paper focusses on the managerial approach, the implementation strategy and provides a holistic process that can be generally adapted across the construction industry. In order to complement current research as well as to specify and deepen the reasons behind these barriers, qualitative expert interviews were conducted next.

3. Qualitative Expert Interviews to Answer Research Question 2

In order to answer the second research question (What are the current barriers for implementing digital tools in the construction industry?), an empirical study with expert interviews was conducted. This approach provided two benefits. On the one hand, the initial findings from the literature and the answers to Research Question 1 could be validated deductively, and on the other hand, the expertise of the interview partners could lead to further findings, which thereby could be collected inductively [52–55]. Therefore, a qualitative empirical method was chosen to collect the data, as this provides the necessary scope for the experts [52,53,56]. The methods of research interviews represent a further specification, as the elicited knowledge can only be recorded verbally [57–59]. The necessary expertise coupled with the need for a general and holistic perspective on the object of the investigation within the surveyed companies results in the qualitative data being collected through expert interviews [60–62]. To be able to compare the findings and to achieve the necessary level of detail, these are conducted in a semi-structured manner.

3.1. Survey Instruments and Adaptation

The semi-structured expert interviews are based on the survey instruments *Technology Commitment* by Neyer et al. [63] and *Technophobia* by Sinkovics [64]. The two instruments have been validated and tested and thus represent a scientific basis that can be adapted for the present purpose. Figure 4 visualizes the adaptation process for the conducted survey.

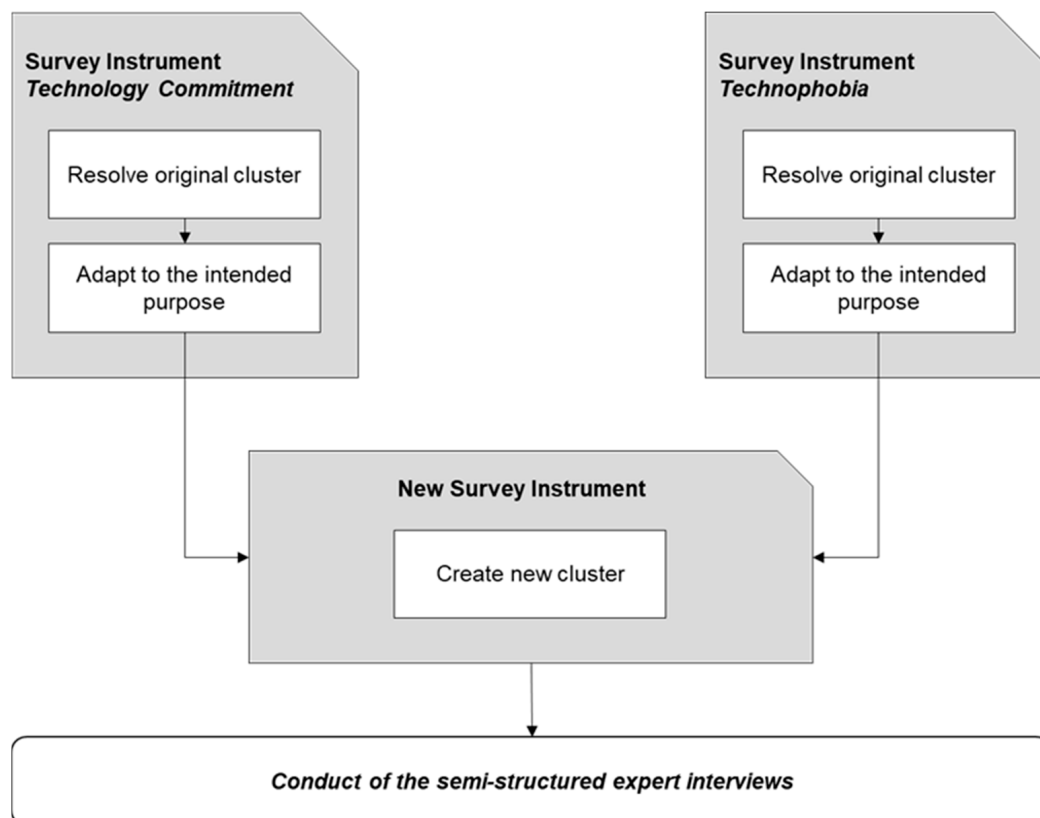


Figure 4. Adapting the two survey instruments *Technology Commitment* by Neyer et al. [63] and *Technophobia* by Sinkovics [64] for semi-structured expert interviews with construction companies.

For the adaptation of the quantitative questionnaires from the two survey instruments, the existing clusters *Personal Failure*, *Human vs. Machine-Ambiguity* and *Convenience* from Sinkovics [64] were dissolved in a first step. Afterwards, the individual statements were modified and adapted to be used as a basis for discussion in the qualitative expert interviews. For this purpose, the core of the individual statements was retained, but the content was related to construction so that the statements can be interpreted and answered from the perspective of the construction companies. The statements were also kept general to apply for and include all digital technologies. The polarity of the statements was retained for later evaluation. By combining the modified and adapted statements of both measuring instruments, three new result clusters *Acceptance*, *Competence* and *Control* were derived from Neyer et al. [63,65]. Table 3 lists the new clusters, the corresponding and modified statements as well as the origin from the original survey instruments. By conducting the survey and breaking the answers of the construction companies down to the clusters, the readiness for the use and implementation of digital technologies could be determined.

Table 3. Statements of the new survey instrument.

Cluster	Statement	Origin *
Acceptance	(1.1) The company is always open towards digital technologies	A
	(1.2) Digital technologies are quickly adopted and integrated within the company	A
	(1.3) The company is always interested in using the latest digital technologies	A
	(1.4) If there were the possibility, the company would use even more digital technologies	A
	(1.5) Digital technologies are well accepted in the company	B
	(1.6) Digital technologies make work easier for employees in the company	B
	(1.7) Digital technologies create added value for the company	B
Competence	(2.1) Employees mostly do not fail in the use of digital technologies	A
	(2.2) Dealing with digital technologies does not usually lead to employees being excessively demanded	A
	(2.3) Employees use digital technologies correctly without causing harm	A
	(2.4) Dealing with digital technologies does not lead to a loss of control and self-doubt among employees	A
	(2.5) The use of digital technologies leads to uncertainty	B
	(2.6) Digital technologies cause conflicts in the company	B
	(2.7) Other companies are more practised in the use of digital technologies	B
	(2.8) The use of digital technologies leads to frustration	B
	(2.9) The use of digital technologies leads to nervousness	B
	(2.10) There is uncertainty in the introduction of digital technologies	B
Control	(3.1) The implementation of digital technologies depends on individual employees	A
	(3.2) The successful use of digital technologies depends on individual employees	A
	(3.3) Only little outside support can be provided for the use of digital technologies	A
	(3.4) The use of digital technologies creates ownership among employees	A
	(3.5) Digital technologies reduce personal contact in the company	B
	(3.6) The use of digital technologies should be mandatory	B
	(3.7) Trust in digital technologies is not entirely present	B
	(3.8) The use of digital technologies should be autonomous	B

* (A) Adapted from the survey instrument Technology Commitment by Neyer et al. [63] and (B) from the survey instrument Technophobia by Sinkovics [64].

3.2. Selection of Interviewed Companies

Experts from the largest German construction companies were interviewed for the qualitative interviews. Experts were defined as persons who, on the one hand, have a holistic perspective on the company and, at the same time, can demonstrate expertise in digital tools. The list of the largest German construction companies from July 2021 compiled by the Main Association of the German Construction Industry served as a template [66]. In order to ensure valid comparability of the companies, further conditions were defined for the inclusion into or exclusion from the study. These were a minimum number of employees of at least 1000 and an annual turnover of more than 500,000,000 EUR achieved in Germany alone. Furthermore, companies must be predominantly active in building construction and in B2B business. The following table shows the resulting 15 companies and additional information. Due to the fact that more than two-thirds of the companies surveyed also operate outside of Germany and the questions do not assess country-specific details, the findings provide a general picture [66].

3.3. Results

For the individual expert interviews, a five-point scale was utilized using the answer options *not at all true* (1), *a bit true* (2), *partly true* (3), *true quite a bit* (4) and *completely true* (5) and the statements were evaluated accordingly. The polarity of the statements was formulated that the lower the score, the more the corresponding statement or the cluster is representing a barrier for the implementation process of digital technologies. Statements or clusters with a high score, on the other hand, can therefore be interpreted as a good rating and are not currently seen as a barrier. This made it possible to compare the clusters as a whole and to determine individual statements that deviate strongly from the mean value within a cluster. Of the 15 identified companies, 14 agreed to an interview. Anonymity of the individual evaluations is preserved, as the individual statements do not contribute any added value to the solution of the research questions.

Figure 5 shows the number of overall points awarded. It is striking that a total of 40% were given the rating 4. Furthermore, about 30% of the statements were rated 3, which means partial agreement. A 5 was given almost as often as the sum of 1 and 2, which clearly shows that a clear agreement or disagreement was only given in about 30%. Overall, it can also be derived that the average score awarded is 3.5.

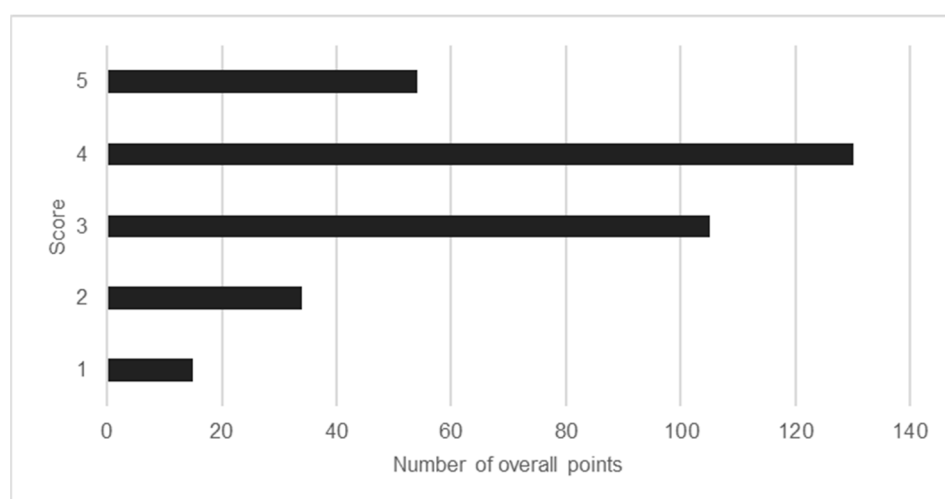


Figure 5. Total score distribution over all questions and companies.

With a maximum deviation of 0.5 from the average score (3.5), all surveyed companies stay within a close range to each other, as shown in Figure 6. As this picture emerges, it can further be deduced, that the general assessment by the expert regarding the implementation of digital technologies within the construction industry is comparable.

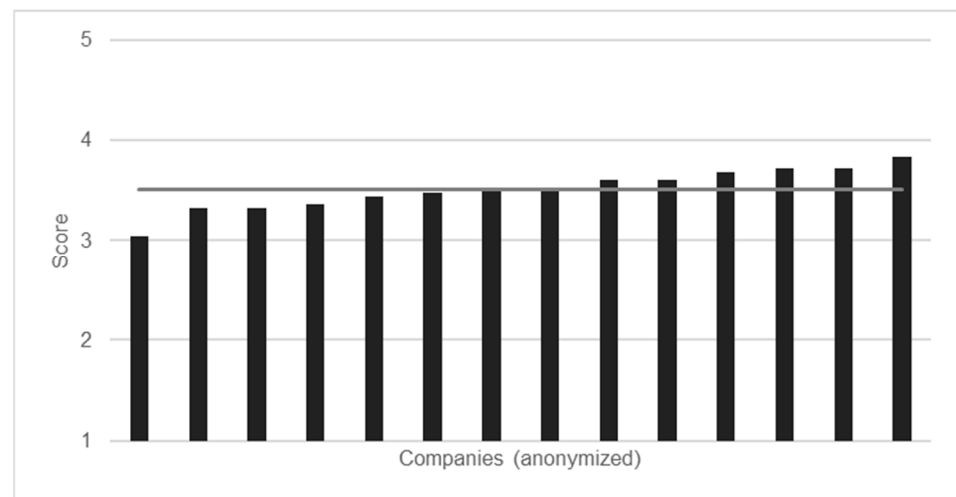


Figure 6. Average score per company (anonymized).

Figure 7 visualizes the evaluation from a cluster-wide level and shows the average results for the three previously defined clusters *Acceptance*, *Control* and *Competence*. It is noticeable that the statements in the *Acceptance* (4.0) cluster were rated best. Therefore, according to the survey and the experts, general acceptance of digital technologies is high among all companies in the construction industry. A similar picture emerges for the cluster *Competence* (3.7). Here, the experts agreed to the majority of the statements. It also becomes clear that *Control* (2.9) is the cluster with the lowest rating.

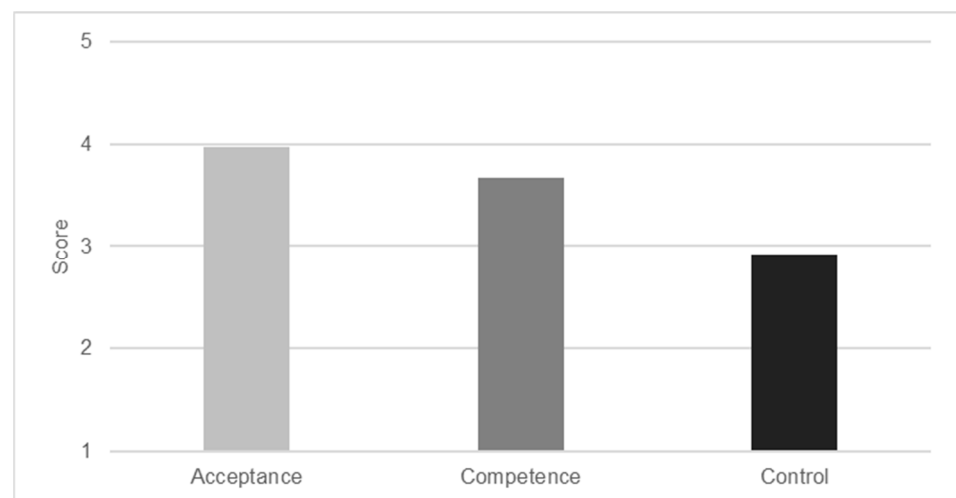


Figure 7. Average score of the clusters *Acceptance*, *Competence* and *Control* over all companies.

Lastly, Figure 8 shows the evaluation of the individual categories of the expert interviews. Here, the average rating per statement and category is shown across all interviewed companies. As explained above, the lack of agreement with the category *Control* can also be derived here. Furthermore, the individual statements in the categories *Acceptance* and *Competence* were rated similarly, and no statement stands out significantly. In contrast, a greater discrepancy can be seen in the statements of the category *Control*. Statements 3.2 (Score: 2.0) and 3.6 (Score: 2.0) in particular deviate strongly from the average value of the category. These will be taken up again in the discussion and examined more closely.

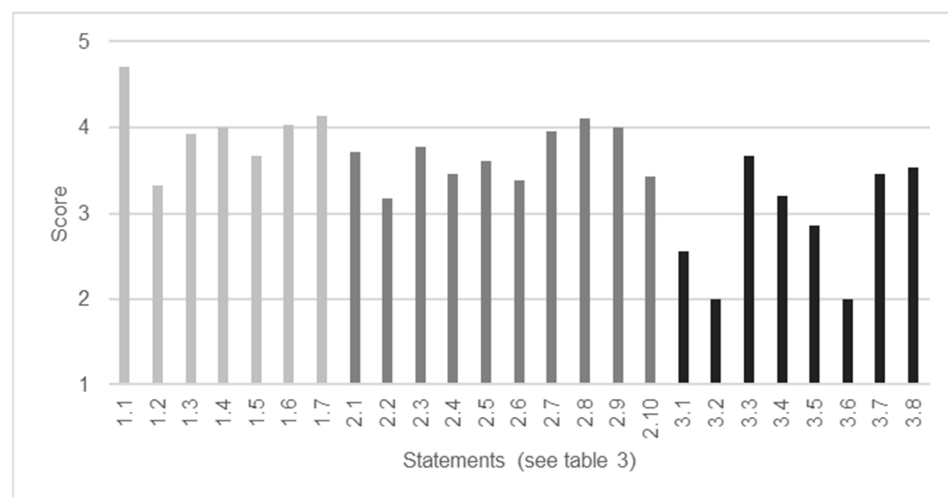


Figure 8. Average score per statement over all companies.

From the results of the expert interviews, it becomes evident that barriers for implementing digital technologies in the construction industry are present to varying degrees. When considering a low evaluation score as a barrier, the average score 2.9 in the cluster *Control* as well as the statements 3.2 (Score: 2.0) and 3.6 (Score: 2.0) indicate current barriers.

4. Discussion

The use of digital tools has a key impact on the improvement of the sustainability of organizations [67] and heavily depends on the implementation process. The implementation can only be successfully established through a predefined framework and guidelines. For these, the three characteristics of competence, control and acceptance in the company needs to provide a strong foundation. The specification of a framework confirms the desire derived from statement 3.6 to strengthen the obstacle of control. Likewise, a clearly defined framework ensures that all employees involved are integrated at the appropriate time, which counteracts weaknesses from statement 3.2.

As a general solution, the findings must be integrated into a holistic digital technology implementation model to generalize existing but fragmented processes and bridge the knowledge gap for construction companies when implementing digital technologies in the future [20]. This procedure also seeks a solution to Research Question 3 on how digital tools can be introduced in the future as a holistically optimized process. For this purpose, the Cambridge Business Model Innovation Process by Geissdoerfer et al. [68] was selected as it places particular emphasis on the practical benefits and the model has already been adapted several times. Figure 9 shows the adapted model which explicitly integrates the findings from the expert interviews and is thereby adapted for the construction sector.

It should be pointed out that different barriers prevail and originate in the different phases when looking at the implementation of digital technologies. For example, the necessary competence must be available from the beginning via the involvement of experts which is expressed in the further course through control and responsibility. Acceptance is particularly important in the last step of the adopted model, which is supported by the control and competence that already prevail here. Recommendations for action are made for successful implementation, which were considered sensible and necessary in the individual phases.

Competence is most important in the ideation and concept design sub-processes. While the experts rate the competence in the construction industry relatively high with 3.7 out of 5, the competence of employees and the management board is still recognized as one of the major barriers [18]. However, contributing new and innovative ideas on digital technologies which could optimize workflows should be explicitly encouraged among all employees, as Li and Gu [25] and Sepasgozar and Davis [50] also mention. A goal should

be defined as clearly as possible right in the beginning so that a joint expectation prevails throughout the subsequent phases. For this, it is significant to identify the exact area of application and possible links with other digital technologies. This can only be achieved by involving all stakeholders [18]. The various competences are therefore already required in the conceptual design sub-process, generating a certain ownership which can be an essential basis for the necessary acceptance in the subsequent phases and especially during implementation. Involving experts also counteracts either uncertainties that may arise or impending excessive demands [18] (according to statement 2.2 and 2.4). In addition to the involvement of experts, all persons who will have to work with it or whose work is linked to it must also be involved. Furthermore, these aspects are closely linked to a necessary financial clarity noted by Bajpai and Misra [6]. Finally, the management level, which has the responsibility for decision-making, should also be integrated and convinced of the idea and the digital technology [6]. In addition to creating competence, the involvement of all stakeholders can also counteract conflicts (according to statement 2.6).

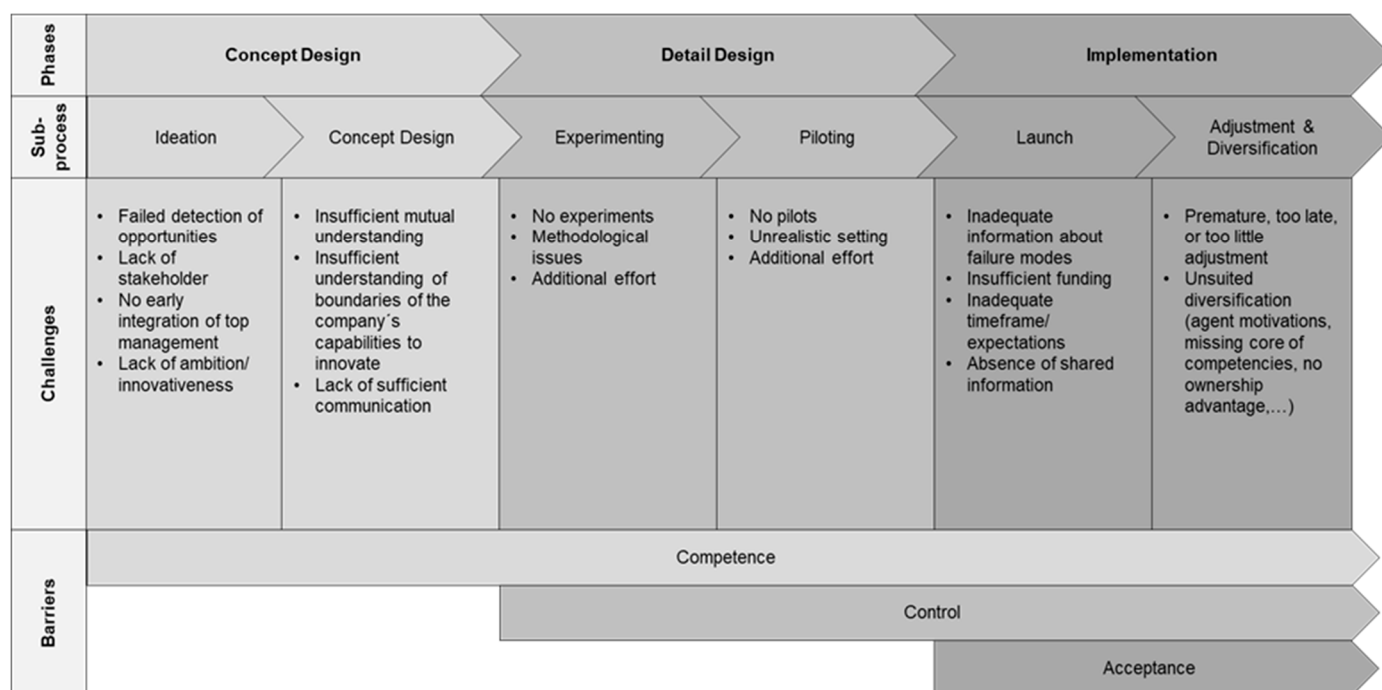


Figure 9. Holistic digital technology implementation process for construction companies which addresses current barriers (adopted from the Cambridge Business Model Innovation Process by Geissdoerfer et al. [69]).

Control, which in the opinion of the experts is currently seen most critically and is also underlined as a current barrier by Bajpai and Misra [6] and Tabatabaee et al. [21], comes to the fore in the detailed design phase, with the sub-processes of experimenting and piloting. However, appropriate competence is still necessary, which can also be ensured in this phase through the systematic involvement of the relevant people [69]. During the sub-process experimentation, it is important that all participants are aware that the process is an initial trial that is predominantly theoretical and that exact details can be defined through subsequent analysis [69]. Due to a predominant focus on these individual details, control is often not present in this sub-process [69]. Accordingly, it is recommended to define a schedule with predefined decision points in advance, thus the testing and subsequent analysis can be carried out in time and in a controlled manner (according to statement 3.6). To this end, it is of particular importance to check and ensure internal and, above all, external support (according to statement 3.3) as well as strict independence from individual software solutions. In fact, for the subsequent piloting sub-process, several

software solutions should be used. Here, special emphasis should be placed on a precise risk analysis of the (inter-)organizational interfaces [70,71]. Providing clarity about these is an essential factor for an increase in acceptance and control [24]. In addition, training opportunities, which Ramilo and Embi [51] address as a necessity, become especially relevant here and will stay relevant along all subsequent phases. During the piloting sub-process, it is recommended to test the digital technology on various small projects, even in parallel whenever possible. This allows for a better comparison and broad feedback in a short time span. It is also important to clearly define the framework conditions in the piloting sub-process, as this preserves control over the testing and the subsequent analysis [18]. It is further explicitly stated that both sub-processes, experimenting and piloting, should be carried out [18]. The two sub-processes should also be considered decoupled from each other to enhance control in either sub-process.

The last of the three overarching phases, implementation, is characterized by acceptance as a successful introduction can only take place if the commitment and approval of the actors involved is present [21]. It is crucial that this commitment is obtained in advance from all of those that were previously involved throughout all organizational levels [18]. In addition, control and competence created in the previous phases remain significant. Acceptance, especially in the launch phase, depends on clarity about temporal, monetary and qualitative factors which are in turn ensured by the competence and control gained through the previous phases. Furthermore, the acceptance of individuals is higher if the framework conditions, the limits and the influence of the application area are explained clearly [18]. This also makes it easier to assess the added value for each individual participant (according to statement 1.6). In order to successfully implement a digital technology, it is necessary to plan the adjustment phase, which can extend over a long period of time. Here, the next steps and the ownership, as well as the responsibility, should be clearly defined. It is also recommended to design the organizational interfaces as openly as possible so that further adaptations and connections can be made easily [35,72]. Among other things, this creates motivation and enthusiasm for further projects (according to statement 1.3 and 1.4).

Although the qualitative expert interviews give valuable insights into current challenges in Germany's construction companies, the methodology is based on a limited sample size and, at the same time, narrows the results on barriers and challenges regarding the implementation of digital technologies down to the German perspective. In addition, the adapted holistic digital technology implementation process used is only one possible approach. Adapting and comparing the implementation process chosen in this paper with implementation processes used in other industries could e.g., be achieved by extending the literature review methodology and thereby getting even more comprehensive results from the research field.

5. Conclusions and Future Research

In terms of digitalisation, the construction industry is lagging behind other industries. However, with various digital technologies available for a wide variety of applications, the questions arise of how digital technologies are currently implemented and what barriers are currently hindering this implementation process, according to the literature (Research Question 1), as well as construction companies (Research Question 2). Bringing these findings together, this paper also seeks a holistic implementation process for digital technologies which addresses current barriers (Research Question 3).

To answer the first research question, a qualitative literature review was conducted. Thereby, the picture emerged that several publications are country-specific which means that the topics dealt with are strongly influenced by the framework of conditions in individual countries. It is also evident that a large proportion of the publications focus on topics related to BIM. Another part deals with individual technologies, which are not placed in a holistic context. There are also articles that deal with overarching problems and in some cases present obstacles. However, the reviewed literature gave no input on a holistic

implementation process for digital technologies. In addition, a lack of socio-technical factors was identified as the majority of articles entirely focus on technical aspects. Based on the findings of the qualitative literature review, expert interviews were conducted, which revealed the prevailing opinion from practice. The results showed that there is acceptance and competence for the use and implementation of digital technologies. According to the experts, control is not present to the same extent and thus currently represents the greatest obstacle. The necessity of each individual for successful use as well as the obligation to use can be classified as a major barrier. These topics in particular were therefore considered in the clarification of the third research question. Based on the Cambridge Business Model Innovation Process by Geissdörfer [69], a holistic implementation process for digital technologies in construction companies was developed which addresses current barriers. The adapted phases were assigned recommendations for action which on the one hand precisely address the barriers identified and on the other hand provide standardisation and structure for the future introduction of digital tools. The implementation process presented is intended to reduce the current barriers to the introduction of digital technologies in the future and to ensure a successful implementation.

In future research, the barriers for SMEs should be examined, as their company structure is different due to their size, and the focus is influenced more strongly, for instance, by monetary aspects. Likewise, the barriers should be examined in more detail. In addition, the analysis of barriers on a socio-technical level and on an economic level requires further investigation. With regard to the implementation process, continuous improvement as well as adaptation and adjustment to individual areas should be strived for. The measurability of the implementation on the one hand and the use of digital technologies on the other hand is also an area that research should focus on in order to make decisions assessable in the future.

Author Contributions: Conceptualization, methodology, software, validation, formal analysis, investigation, data curation, writing—original draft preparation, and visualization, P.S. and P.H.; writing—review and editing, and project administration P.S., P.H. and H.C.J.; supervision H.C.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to the permission of the expert of the interviews.

Acknowledgments: We would like to thank the companies and especially the experts who provided their expertise and valuable insights for our research. This made it possible to discuss the current obstacles empirically and qualitatively.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chen, X.; Chang-Richards, A.Y.; Pelosi, A.; Jia, Y.; Shen, X.; Siddiqui, M.K.; Yang, N. Implementation of Technologies in the Construction Industry: A Systematic Review. *Eng. Constr. Archit. Manag.* **2021**, *29*, 3181–3209. [CrossRef]
2. Olanipekun, A.O.; Sutrisna, M. Facilitating Digital Transformation in Construction—A Systematic Review of the Current State of the Art. *Front. Built Environ.* **2021**, *7*, 660758. [CrossRef]
3. Singh, V. Digitalization, BIM Ecosystem, and the Future of Built Environment: How Widely Are We Exploring the Different Possibilities? *Eng. Constr. Archit. Manag.* 2019; *ahead-of-print*. [CrossRef]
4. Deutsche Telekom AG. Corporate Communications Baugewerbe 2020/2021—Digitalisierungsindex. Available online: <https://www.digitalisierungsindex.de/studie/digitale-transformation-baugewerbe-2021/> (accessed on 4 March 2022).
5. Gandhi, P.; Khanna, S.; Ramaswamy, S. Which Industries Are the Most Digital (and Why)? *Harv. Bus. Rev.* **2016**, *1*, 45–48.
6. Bajpai, A.; Misra, S.C. Barriers to Implementing Digitalization in the Indian Construction Industry. *Int. J. Qual. Reliab. Manag.* **2021**, *39*, 2438–2464. [CrossRef]

7. Jin, R.; Zou, Y.; Gidado, K.; Ashton, P.; Painting, N. Scientometric Analysis of BIM-Based Research in Construction Engineering and Management. *Eng. Constr. Archit. Manag.* **2019**, *26*, 1750–1776. [\[CrossRef\]](#)
8. Hu, W.; Dong, J.; Hwang, B.; Ren, R.; Chen, Z. A Scientometrics Review on City Logistics Literature: Research Trends, Advanced Theory and Practice. *Sustainability* **2019**, *11*, 2724. [\[CrossRef\]](#)
9. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *BMJ* **2021**, *372*, n71. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Snyder, H. Literature Review as a Research Methodology: An Overview and Guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [\[CrossRef\]](#)
11. Cerchione, R.; Esposito, E. A Systematic Review of Supply Chain Knowledge Management Research: State of the Art and Research Opportunities. *Int. J. Prod. Econ.* **2016**, *182*, 276–292. [\[CrossRef\]](#)
12. Arvianto, A.; Sopha, B.M.; Asih, A.M.S.; Imron, M.A. City Logistics Challenges and Innovative Solutions in Developed and Developing Economies: A Systematic Literature Review. *Int. J. Eng. Bus. Manag.* **2021**, *13*, 184797902110397. [\[CrossRef\]](#)
13. Salim, H.K.; Stewart, R.A.; Sahin, O.; Dudley, M. Drivers, Barriers and Enablers to End-of-Life Management of Solar Photovoltaic and Battery Energy Storage Systems: A Systematic Literature Review. *J. Clean. Prod.* **2019**, *211*, 537–554. [\[CrossRef\]](#)
14. Vilela, J.; Castro, J.; Martins, L.E.G.; Gorschek, T. Integration between Requirements Engineering and Safety Analysis: A Systematic Literature Review. *J. Syst. Softw.* **2017**, *125*, 68–92. [\[CrossRef\]](#)
15. Hosseini, M.R.; Martek, I.; Zavadskas, E.K.; Aibinu, A.A.; Arashpour, M.; Chileshe, N. Critical Evaluation of Off-Site Construction Research: A Scientometric Analysis. *Autom. Constr.* **2018**, *87*, 235–247. [\[CrossRef\]](#)
16. Oraee, M.; Hosseini, M.R.; Papadonikolaki, E.; Palliyaguru, R.; Arashpour, M. Collaboration in BIM-Based Construction Networks: A Bibliometric-Qualitative Literature Review. *Int. J. Proj. Manag.* **2017**, *35*, 1288–1301. [\[CrossRef\]](#)
17. Xiang, C.; Wang, Y.; Liu, H. A Scientometrics Review on Nonpoint Source Pollution Research. *Ecol. Eng.* **2017**, *99*, 400–408. [\[CrossRef\]](#)
18. Bosch-Sijtsema, P.; Claeson-Jonsson, C.; Johansson, M.; Roupe, M. The Hype Factor of Digital Technologies in AEC. *Constr. Innov.* **2021**, *21*, 899–916. [\[CrossRef\]](#)
19. Nwaogu, J.M.; Chan, A.P.C.; Naslund, J.A.; Hon, C.K.H.; Belonwu, C.; Yang, J. Exploring the Barriers to and Motivators for Using Digital Mental Health Interventions among Construction Personnel in Nigeria: Qualitative Study. *JMIR Form. Res.* **2021**, *5*, e18969. [\[CrossRef\]](#)
20. Reyes, P.; Suresh, S.; Renukappa, S. The Adoption of Big Data Concepts for Sustainable Practices Implementation in the Construction Industry. In Proceedings of the Proceedings—11th IEEE/ACM International Conference on Utility and Cloud Computing Companion, UCC Companion 2018, Zurich, Switzerland, 17–20 December 2018; pp. 341–348.
21. Tabatabaee, S.; Mohandes, S.R.; Ahmed, R.R.; Mahdiyar, A.; Arashpour, M.; Zayed, T.; Ismail, S. Investigating the Barriers to Applying the Internet-of-Things-Based Technologies to Construction Site Safety Management. *Int. J. Environ. Res. Public Health* **2022**, *19*, 868. [\[CrossRef\]](#)
22. Atkinson, L.; Amoako-Attah, J.; B-Jahromi, A. Government's Influence on the Implementation of BIM. In Proceedings of the Computing in Civil and Building Engineering—Proceedings of the 2014 International Conference on Computing in Civil and Building Engineering, Orlando, FL, USA, 23–25 June 2014; pp. 520–527.
23. Bew, M.; Underwood, J.; Wix, J.; Storer, G. *Going BIM in a Commercial World*; Zarli, A., Scherer, R., Eds.; EWORK AND EBUSINESS IN ARCHITECTURE, ENGINEERING AND CONSTRUCTION; Taylor & Francis: London, UK, 2009; pp. 139–150.
24. Jin, R.; Hancock, C.M.; Tang, L.; Watanowski, D. BIM Investment, Returns, and Risks in China's AEC Industries. *J. Constr. Eng. Manag.* **2017**, *143*, 12. [\[CrossRef\]](#)
25. Li, Q.; Gu, L.J. Building Information Modeling (BIM) Should Be Promoted in Construction Firm. In Proceedings of the 2nd Global Conference on Civil, Structural and Environmental Engineering, GCCSEE 2013, Volumes 838–841. Shenzhen, China, 28–29 September 2013.
26. Smith, P. BIM Implementation—Global Strategies. *Procedia Eng.* **2014**, *85*, 482–492. [\[CrossRef\]](#)
27. Dainty, A.; Leiringer, R.; Fernie, S.; Harty, C. BIM and the Small Construction Firm: A Critical Perspective. *Build. Res. Inf.* **2017**, *45*, 696–709. [\[CrossRef\]](#)
28. Zou, Y.; Kiviniemi, A.; Jones, S.W. A Review of Risk Management through BIM and BIM-Related Technologies. *Saf. Sci.* **2017**, *97*, 88–98. [\[CrossRef\]](#)
29. Hautala, K.; Järvenpää, M.-E.; Pulkkinen, P. Digitalization Transforms the Construction Sector throughout Asset's Life-Cycle from Design to Operation and Maintenance. *Stahlbau* **2017**, *86*, 340–345. [\[CrossRef\]](#)
30. Zuo, J. The Study on Optimized Program of Landscape Engineering Based on BIM Technology. In Proceedings of the 1st EAI International Conference on Multimedia Technology and Enhanced Learning, Inner Mongolia, China, 13–15 August 2016; EAI: Inner Mongolia, China, 2017.
31. Ghosh, A.; Edwards, D.J.; Hosseini, M.R.; Al-Ameri, R.; Abawajy, J.; Thwala, W.D. Real-Time Structural Health Monitoring for Concrete Beams: A Cost-Effective 'Industry 4.0' Solution Using Piezo Sensors. *Int. J. Build. Pathol. Adapt.* **2021**, *39*, 283–311. [\[CrossRef\]](#)
32. Hassan Ibrahim, N. Reviewing the Evidence: USE of Digital Collaboration Technologies in Major Building and Infrastructure Projects. *J. Inf. Technol. Constr.* **2013**, *18*, 40–63.

33. Oke, A.E.; Aghimien, D.O.; Aigbavboa, C.O.; Koloko, N. Challenges of Digital Collaboration in the South African Construction Industry. In Proceedings of the International Conference on Industrial Engineering and Operations Management, Bandung, Indonesia, 6–8 March 2018; pp. 2472–2482.
34. Sepasgozar, S.M.E. Digital Technology Utilisation Decisions for Facilitating the Implementation of Industry 4.0 Technologies. *Constr. Innov.* **2021**, *21*, 476–489. [\[CrossRef\]](#)
35. Lokshina, I.V.; Greguš, M.; Thomas, W.L. Application of Integrated Building Information Modeling, Iot And. *Procedia Comput. Sci.* **2019**, *160*, 497–502. [\[CrossRef\]](#)
36. Singh, P. Blockchain Based Security Solutions with IoT Application in Construction Industry. *IOP Conf. Ser. Earth Environ. Sci.* **2020**, *614*, 012052. [\[CrossRef\]](#)
37. Elnabawi, M.H.; Hamza, N. Investigating Building Information Model (BIM) to Building Energy Simulation (BES): Interoperability and Simulation Results. *IOP Conf. Ser. Earth Environ. Sci.* **2019**, *397*, 012013. [\[CrossRef\]](#)
38. Jia, J.; Dou, S.; Yang, S.; Wu, Y.; Cao, F.; Li, B.; Cui, H. Study on the Application Framework of BIM in the Life Cycle Management of Offshore Wind Farms. In Proceedings of the International Offshore and Polar Engineering Conference, Honolulu, HI, USA, 16–21 June 2019; Volume 1, pp. 513–520.
39. Afzal, M.; Shafiq, M.T.; Al Jassmi, H. Improving Construction Safety with Virtual-Design Construction Technologies—A Review. *J. Inf. Technol. Constr.* **2021**, *26*, 319–340. [\[CrossRef\]](#)
40. Rey, R.O.; de Melo, R.R.S.; Costa, D.B. Design and Implementation of a Computerized Safety Inspection System for Construction Sites Using UAS and Digital Checklists—Smart Inspects. *Saf. Sci.* **2021**, *143*, 105430. [\[CrossRef\]](#)
41. Pahomova, E.G.; Monastyrev, P.V.; Mishchenko, E.S.; Yezerskiy, V.A.; Ivanov, I.A.; Balthazar, A.D. House-Building Analysis When Using Additive Technologies: Classification, Advantages and Disadvantages. *J. Appl. Eng. Sci.* **2019**, *17*, 449–456. [\[CrossRef\]](#)
42. Chowdhury, T.; Adafin, J.; Wilkinson, S. Review of Digital Technologies to Improve Productivity of New Zealand Construction Industry. *J. Inf. Technol. Constr.* **2019**, *24*, 569–587. [\[CrossRef\]](#)
43. Hwang, B.-G.; Ngo, J.; Her, P.W.Y. Integrated Digital Delivery: Implementation Status and Project Performance in the Singapore Construction Industry. *J. Clean. Prod.* **2020**, *262*, 121396. [\[CrossRef\]](#)
44. Won, D.; Hwang, B.-G.; Binte Mohd Samion, N.K. Cloud Computing Adoption in the Construction Industry of Singapore: Drivers, Challenges, and Strategies. *J. Manag. Eng.* **2022**, *38*, 05021017. [\[CrossRef\]](#)
45. Singh, A.; Misra, S.C. Identifying Challenges in the Adoption of Industry. In *Progress in Advanced Computing and Intelligent Engineering*; Springer: Singapore, 2021; Volume 1198.
46. Koscheyev, V.; Hakimov, A. Russian Practice of Using Digital Technologies in Public Procurement Management in the Construction Industry. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *497*, 012009. [\[CrossRef\]](#)
47. Turkova, V.N.; Archipova, A.N.; Fedorovna, Z.G. Digital Transformation of the Russian Construction Industry. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *880*, 012083. [\[CrossRef\]](#)
48. Olawumi, T.O.; Chan, D.W.M. Developing Project Evaluation Models for Smart Sustainable Practices Implementation in Construction Projects: A Comparative Study between Nigeria and Hong Kong. *Eng. Constr. Archit. Manag.* **2021**, *29*, 1522–1552. [\[CrossRef\]](#)
49. Awuzie, B.; Monyane, T. Achieving Sustainable Construction in South Africa through Digitalization: An Exploratory Study. In Proceedings of the 22nd International Conference on Advancement of Construction Management and Real Estate, CRIOCM 2017, Victoria, Australia, 20–23 November 2017; pp. 935–942.
50. Sepasgozar, S.; Davis, S. Construction Technology Adoption Cube: An Investigation on Process, Factors, Barriers, Drivers and Decision Makers Using NVivo and AHP Analysis. *Buildings* **2018**, *8*, 74. [\[CrossRef\]](#)
51. Ramilo, R.; Embi, M.R.B. Critical Analysis of Key Determinants and Barriers to Digital Innovation Adoption among Architectural Organizations. *Front. Archit. Res.* **2014**, *3*, 431–451. [\[CrossRef\]](#)
52. Döring, N.; Bortz, J.; Pöschl, S.; Werner, C.S.; Schermelleh-Engel, K.; Gerhard, C.; Gäde, J.C. *Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften*, 2016th ed.; Springer: Berlin/Heidelberg, Germany, 2015; ISBN 978-3-642-41088-8.
53. Jonker, J.; Pennink, B. *The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science*, 2010th ed.; Springer: Berlin/Heidelberg, Germany; Dordrecht, The Netherlands; London, UK; New York, NY, USA, 2010; ISBN 978-3-540-71658-7.
54. Reichertz, J. Empirische Sozialforschung und soziologische Theorie. In *Handbuch Methoden der empirischen Sozialforschung*; Baur, N., Blasius, J., Eds.; Springer Fachmedien: Wiesbaden, Germany, 2019; pp. 31–48. ISBN 978-3-658-21308-4.
55. Saunders, M.; Lewis, P.; Thornhill, A. *Research Methods for Business Students*, 8th ed.; Pearson Education Limited: New York, NY, USA, 2019; ISBN 978-1-292-20878-7.
56. Baur, N.; Blasius, J. Methoden der empirischen Sozialforschung—Ein Überblick. In *Handbuch Methoden der Empirischen Sozialforschung*; Baur, N., Blasius, J., Eds.; Springer Fachmedien: Wiesbaden, Germany, 2019; pp. 1–28. ISBN 978-3-658-21308-4.
57. Kaya, M. Verfahren der Datenerhebung. In *Methodik der Empirischen Forschung*; Albers, S., Klapper, D., Konradt, U., Walter, A., Wolf, J., Eds.; Gabler Verlag: Wiesbaden, Germany, 2009; pp. 49–64. ISBN 978-3-322-96406-9.
58. Klandt, H.; Heidenreich, S. *Empirische Forschungsmethoden in der Betriebswirtschaftslehre: Von der Forschungsfrage zum Untersuchungsdesign, eine Einführung*; De Gruyter Oldenbourg: Berlin, Germany, 2017; ISBN 978-3-486-70972-8.
59. Schnell, R.; Hill, P.B.; Esser, E. *Methoden Der Empirischen Sozialforschung*; De Gruyter Oldenbourg: Berlin, Germany; Boston, MA, USA, 2018; ISBN 978-3-11-057732-7.

60. Bogner, A.; Littig, B.; Menz, W. *Experteninterviews: Theorien, Methoden, Anwendungsfelder*; VS Verlag für Sozialwissenschaften: Wiesbaden, Germany, 2009; ISBN 978-3-531-16259-1.
61. Helfferich, C. Leitfaden- und Experteninterviews. In *Handbuch Methoden der Empirischen Sozialforschung*; Baur, N., Blasius, J., Eds.; Springer Fachmedien: Wiesbaden, Germany, 2019; pp. 669–686. ISBN 978-3-658-21308-4.
62. Kaiser, R. *Qualitative Experteninterviews: Konzeptionelle Grundlagen und praktische Durchführung*; Springer VS: Wiesbaden, Germany, 2021; ISBN 978-3-658-30254-2.
63. Neyer, F.J.; Felber, J.; Gebhardt, C. Kurzskala Technikbereitschaft (TB, technology commitment). *Zs. Soz. Items Skalen ZIS* **2016**. [[CrossRef](#)]
64. Sinkovics, R. Technophobie. *Zs. Soz. Items Skalen ZIS* **2003**. [[CrossRef](#)]
65. Neyer, F.J.; Felber, J.; Gebhardt, C. Entwicklung Und Validierung Einer Kurzskala Zur Erfassung von Technikbereitschaft. *Diagnostica* **2012**, *58*, 87–99. [[CrossRef](#)]
66. Linden, M. Die 50 Größten Bauunternehmen. Available online: <https://www.bauindustrie.de/zahlen-fakten/die-50-groessten-bauunternehmen> (accessed on 4 March 2022).
67. Geissdoerfer, M.; Vladimirova, D.; Evans, S. Sustainable Business Model Innovation: A Review. *J. Clean. Prod.* **2018**, *198*, 401–416. [[CrossRef](#)]
68. Geissdoerfer, M.; Savaget, P.; Evans, S. The Cambridge Business Model Innovation Process. *Procedia Manuf.* **2017**, *8*, 262–269. [[CrossRef](#)]
69. Aghimien, D.; Aigbavboa, C.; Oke, A. *Digitalisation for Effective Construction Project Delivery in South Africa*; Coventry University: Coventry, UK, 5–6 July 2018.
70. Abu-Reishah, L.; Hiyassat, M.A. The Severity of Design-Construction Interface Risks in Jordanian Construction Industry. *Int. J. Constr. Manag.* **2021**, 1–9. [[CrossRef](#)]
71. Keerthana, K.; Shanmugapriya, S. Role of Interface Management in Construction Industry. *Int. Res. J. Eng. Technol. IRJET* **2017**, *4*, 1217–1220.
72. Kudryavtseva, V.A.; Nikishina, O.V.; Vasileva, N.V. Features of Digital Transformation in the Construction Industry. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *880*, 012080. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.