Data Templates and Digital Building Logbooks boosting Digital Twin in Construction

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Abstract
The construction industry is facing many challenges and several concepts as Data Template Building Logbook and Digital Twin are presented as different solutions to solve the industry challenges. The perception is often that these concepts somehow are fighting each other. To explore supporting action to implementation, a literature review has been conducted. The thematic analysis of the findings was done by use of the Integrated Design and Delivery Solutions framework. A conceptual review was done to explore the potential impact and capability of the concepts of Data Template Building Logbook and Digital Twin. So far has much been published, but limited been implemented in practice of each concept, despite their potential impact. The results indicate that improved understanding, not just development each concept, of the importance on integration between the concepts of Data Template Building Logbook and Digital Twin will contribute to synergies, and by this boosting implementation and innovation.

Keywords: Digitalization, Sustainability, Decision Support, Roadmap, Information Management

1 Introduction

During the last two decades, the Building Information Modelling (BIM) concept has been growing and is widely pointed as the enabling methodology to accomplish most of the Architecture, Engineering, Construction, Operators and Owners (AECOO) industry challenges (Succar & Kassem 2016). Despite interesting adoption levels across the world, there is still a lot of confusion and misunderstanding around it (Hjelseth 2017). The growing production of standards and guidelines is fostering not just improved understanding of its uses/purposes, inherent requirements and processes around, but mainly on the ability to scale the methodology to a broader implementation, based on interoperability principles (buildingSMART 2020).

While the industry is still lacking an overall understanding of BIM, many other concepts have been populating the strategies and roadmaps, namely those focused on digitalization and other construction challenges. Construction 4.0, Internet of Things (IoT), Augmented Reality, Smart Buildings, Smart Built Environment, Common Data Environment, Laser Scanning, among many others, constitute examples of terms and concepts that are gaining relevance every day but are not being followed/well understood by the industry (Turk 2019; Desruelle et al 2019). This vast amount of terms is "the face" of actions that aim to raise the industry's bar.

To achieve the goals of implementing with success innovative actions in construction it is required much more than technological development. The ability to involve the agents and work new or streamlined processes in a collaborative environment is found to potentiate accomplishment. Integrated Design and Delivery Solutions (IDDS) framework assumes Technology, People and Processes as the "three imperatives" to achieve improved outcomes (Owen 2013) and, for the point of view of the research, it is found to be the best approach to provide overall guidance.

However, the terminology often changes or is presented from different perspectives, leading to inaction on a sector that is "labelled" as resistant to change (Forum 2016). This is creating a gap between the strategies - pointing to evolution and implementation of new processes and technologies - and the industry stakeholders get confused regarding the best roadmaps, approaches or their priority goals definition. Inaction causes delays and opting for wrong strategies causes losses. These may occur at several dimensions, where the financial ones are of extreme relevance within an industry that operates with low margins. These failures can contribute to higher resistance to change, demotivation and unproductivity, among others.

To prevent these situations the development of inclusive/integrated approaches that perceive and link/merge concepts are required, as these constitute key benefits for the industry stakeholders working as positioning tools and guidelines.

This research objective is to work on these inclusions by presenting a review on the meanings of different concepts and provide conceptual frameworks to evidence how these can be related and combined. IDDS framework is used and applied to these terms to provide guidance on how to boost digital twins in construction through improved understanding of Data Templates and Digital Building Logbook (DBL) (Dourlens et al 2021).

2 Methods

Literature review is part of methodological approach to evaluate research results and a comprehensive view of current scientific outputs. Given the research objective, the identification of overlaps between the different concepts, iterative study was developed to achieve this goal, but also to obtain a vision on the outputs of each concept individually.

In a first moment and using only the Scopus database, individual search was made using the three following queries: "Data Templates", "Building Logbook" and "Digital Twin". Depending on the number of results, additional words or limitation to subject areas were applied as detailed in the next section. The objective was to narrow down the number of results and to obtain publications within the scope of the research, as some concepts revealed to be broad. Specific review on each concept results was made seeking for studies relating or combining the concepts (Figure 1). Highlights on the addressed topics are presented for each situation.

In a second moment, the same process was performed using as queries the combination of two concepts. In all three situations the outputs were none and therefore the process was repeated on the Web of Science database achieving the same result. This approach and results pointed to a gap in research contributions. Broad database as Google Scholar, was used to confirm the feelings, knowing in advance that potential outputs could be from other types of documents that not just research papers. However, the goal was to identify publications that somehow address or relate more than one concept. The repetition of the abovementioned queries in this database provided results. These are identified in detail in sub-section 3.2.

The review of the different results supports the discussion and the findings. Lack of understanding and blurriness around these and other concepts are not contributing to streamline the innovation efforts. The concepts under research are found to have relation, but their realization is still lacking in most of the works, where concepts are mainly mentioned briefly or with less structured thinking on their relations.

Therefore, conceptual frameworks were produced using IDDS approach, namely Drivers for Change, Enablers, Barriers and Opportunities framework, applied to Digital Data Templates and to Digital Building Logbooks as boosters of Digital Twin Construction.

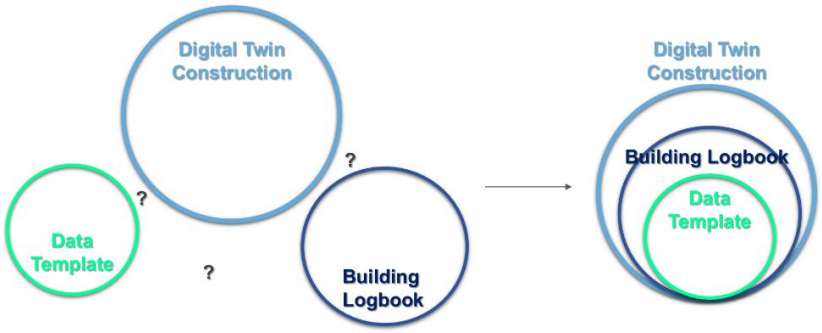

Figure 1. Research question seeking overlap between concepts and ambitioned future headings where concepts clarity provides synergies boosting innovation.

3 Terms, Concepts and their integration

The Digital Twin concept is gaining traction within the industry and despite remaining ill-defined and with little or no consensus among researchers and practitioners, it is a more data-oriented concept, meaning that it suits best to highlight the relevance and importance of Data/Information across the construction life-cycle (Sacks et al 2020). DT's can be applied at several levels, and within the AECOO sector these can range from a construction element; for example an HVAC equipment or system, to the entire Built Environment (Centre for Digital Built Britain et al 2019). To clear the concept and provide examples of implementation there are several H2020 projects addressing this topic (BIM2TWIN, 2020; COGITO Project, 2020). This research focus on DT at Construction Entity level. The elementary concept of a DT is based on the interconnection between a physical element and its digital mirror. Such interconnection goes beyond the transition of data and obtaining information or just a graphical representation (Tchana et al 2019; Fjeld 2020). Considering the HVAC equipment example as part of a construction entity, the DT enables the information and data flows between the physical element and its digital mirror. These can be either equipment characteristics or its performance under an operating situation.

The Digital Building Logbook (DBL) concept aims to express a dynamic tool that works as a common repository of all relevant building data; meaning construction entity data. Some of this data might be more static, while other is more dynamic being updated continuously or following a defined frequency. It is envisaged to facilitate trust, transparency and informed decisions to construction stakeholders (Dourlens et al 2021). This means that if a building has an HVAC equipment and, if considered that its information is relevant, the DBL would be able to support all the data; static and dynamic. Examples of this could be HVAC equipment characteristics as the trademark, dimensions, weight as well as the performance data during operation, as energy consumption, temperature, fan speed, noise, among others.

Considering the definition from ISO 23387 standard, Data Templates are data structures used to describe the characteristics of construction objects. Following this definition, these structures can be used to exchange construction object information for specific purposes in the inception, brief, design, production, operation and demolition of facilities (ISO 2020). It is relevant to frame that a construction entity is composed by multiple built objects. Back to the abovementioned example, this means that Data Templates support HVAC equipment data through the use of standardized data fields and properties.

This brief concepts introduction and examples indicates that there are relevant touchpoints. To support these "feelings" the following sub-section explores the outputs from the literature review.

3.1 Concepts review

The literature review was developed by performing individual and combined searches, querying the different concepts using Scopus database. The outputs were used first to identify touchpoints or overlaps between the concepts and how do the research works approach the topics and

second, to confirm empirical impressions related to the "heat" or scientific dynamic of the same concepts.

Considering the abovementioned definitions and without entering in conceptualizations around the contents or full realization of the different concepts the search process was developed starting with "Digital Twin", preliminary assumed by the authors as the broadest concept, followed by "Digital Building Logbook" and "Data Templates".

3.1.1 Digital Twin

Starting with "Digital Twin", it is important to be aware that this concept is not exclusive to the construction industry (Fjeld 2020). Therefore, and seeking for higher accuracy of the results with the scope of the present paper, the search was divided in two, by adding to DT the words "Construction" and then "Built Environment".

When searching for "Digital" and "Twin" and "Construction", 375 results were obtained. Briefly, it worth's highlighting some of the more common topics within the results. It was observed that some results were out of the industry scope and those identified as part of it refer DT related to BIM, asset management and maintenance, monitoring of processes, improved sustainability and products manufacturing. These topics range most of the construction life-cycle and different types of construction entities. Some results are focused on the combination of DT and Artificial Intelligence (AI) for several purposes. Others, explore the use of DT at building and city scales. Two results were found to be the most relevant related to the scope of this research. The first is from the works developed by Boje, envisaging the directions for future research in semantic construction DT. This relates to data issues and despite the framework using BIM it is stated that DT goes beyond, where BIM can be seen as a sub-component of DT (Boje et al 2020). This suits the vision of DT at the construction entity level. The other work also relates with BIM but the approach is made from the BIM Digital Objects (BDO). BDO's are also known as BIM objects. According to this output, these are composed by several elements, parameters among them, as well as COBie data (Al-Saeed et al 2020). All constitute data, and this can be assumed as properties within the Data Templates. From this results that the DT vision can focus on detailed levels as construction objects.

To confirm this as an "hot topic" within the engineering and architecture research community it is interesting to evidence that 311 results date from 2019 or earlier and that the higher number of results was achieved in 2020 with 146 results.

The second search used "Built environment" combined with "Digital Twin". It was interesting to observe that no results were obtained. This constitutes an interesting finding. The outputs allow comments on the novelty of the concept within the construction and on how the AECOO sector is becoming more enthusiastic about it.

3.1.2 Building Logbook

The following search action used the words "Building" and "Logbook". This concept can be considered more specific, as the use of the word building contribute to frame it within the AECOO sector. However, the search led to a considerable number of results that were completely out of scope. To narrow down the number and to be more accurate with the research goals, specific subject areas as "Engineering", "Computer Science", "Environment" and "Business, Management and Accounting" were selected.

This new definition led to 35 documents. It is interesting to notice that 2021 is the year where a higher number of results is observed, counting a total of 4 and this just until the first half of April.

From the results, the most aligned topics are related with energy efficiency, maintenance, design information and life-cycle costs. There are also situations where the research ranges Construction 4.0 technologies. At this level, Blockchain is the technology that more often appears associated with DBL. At this level, it worth's to highlight the research developed by Turk, where it is stated that Blockchain technology has the ability to improve the reliability and trustworthiness of logbooks (Turk and Klinc 2017).

From the results it is possible to state that the concept is somehow recent in the industry and is still gaining relevance. It worth's to highlight that the reports working on the concepts and definitions of the EU framework for DBL are from July 2020 forward (Dourlens et al 2021). This

reinforces the novelty and minor awareness from research community and from the industry stakeholders.

3.1.3 Data Templates

The term "data template" is known and used across many industries and economic activities. Therefore, such a broad search will necessary lead to many results and most of them out of scope. This was in fact tested, leading to 45612 results. The tentative of narrow down the results by limiting to specific subject areas did not work. To achieve "on scope" results the search involved not just the "data templates" query but also the words "product" and "construction". The ISO 23387 standard specifically mentions that a data template can be used for a product, a system or other type of construction object. However, in practice, most of the works and initiatives prior to the publication of this standard were using the terminology "product data template". This means that this concept is more recognized within the industry, as well as the "construction data template" one. The decision was to develop a search combining both terms, leading to "product data template construction", and limited to "Engineering" and "Business, Management and Accounting" subject areas. The output was 42 results. The highest number of results dates from 2015, in the number of 5. This situation revealed that this topic is somehow "less interesting" when compared with the two others. Yet, it is the one that has older research results. When approaching Data Templates, the topics that more often appear related to it are quality management, lean, product requirements, design management and digitalization/interoperability. At this level, it worth's to highlight one of the most recent documents produced and that is also very aligned with the research goals. The work developed by Spagnolo addresses the systematization of construction products information, defined as Product Data Templates (PDT), to be used in combination with BIM objects to foster more interoperable and efficient construction through the construction life-cycle (Spagnolo et al 2020). In fact, this work reveals similar concerns to those set on this study and related research topics.

3.2 Overview of search results

The combined searches using two from the three terms "Digital Twin", "Building Logbook" and "Product Data Template" on the Scopus and Web of Science databases led to the same surprising result; zero. Despite the author's feelings that there could be few research works ranging more than one of these terms, the absence of outputs was not expected. "Google Scholar" data based was used, seeking a broader range for the search. This search resulted on the following outputs:

- "Digital Twin" and "Building Logbook" – 3 results
- "Digital Twin" and "Product Data Template" – 10 results
- "Building Logbook" and "Product Data Template" – 1 result

Table 1 provides a summary on these outputs and Figure 2 an overview on the individual and combined results from "Scopus" and "Google Scholar" databases.

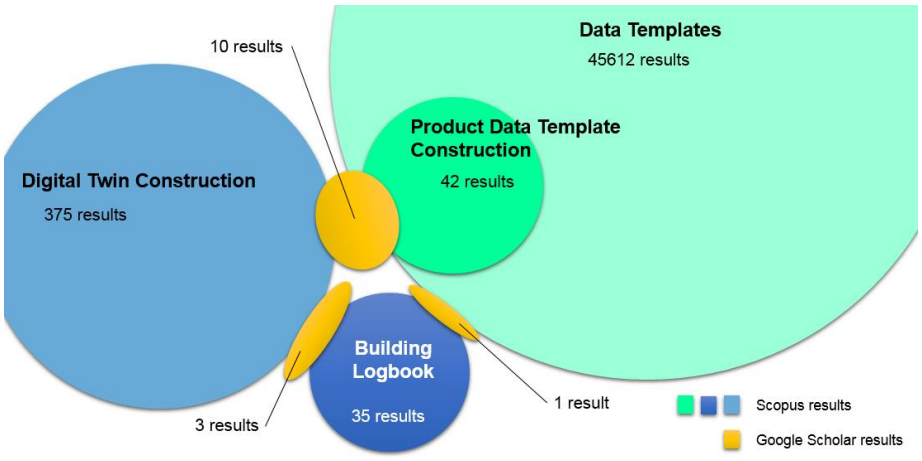

Figure 2. Literature review results from individual and combined concept searches in Scopus and Google Scholar.
Table 1. Systematization of the outputs that came out from the combined concepts query.

Concepts	Output Title	Year	Author
DBL and PDT	Research on Bridging the Information Gap of BIM of interoperability and integration in Facilities Management	2020	Kutaiba, A. et. al.
DT and PDT	The Post-Occupancy Digital Twin: A Quantitative Report on Data Standardisation and Dynamic Building Performance Evaluation	2020	Kirwan, B.
	Urban Semantics in BIM & GIS	2018	Xue, F.
	A framework for product recall in the construction industry	2019	Watson, R.
	Towards a BIM-Based Decision Support System for Integrating Whole Life Cost Estimation into Design Development	2020	Zanni, M.
	Evaluating the Roadmap of 5G Technology Implementation for Smart Building and Facilities Management in Singapore	2020	Chew, MYL.
	Network FOuNTAIN a CDBB network: For ONTologies and information maNagement in digital built Britain	2019	Demian, P.
	A platform for change: How identifying and aligning technology building blocks provides a digital platform of change in the construction industry	2020	Glancy, B.
	Efficient use of digital EPD via ILCD+ EPD+	2019	Erlandsson, M.
	Future Cities in the Making: overcoming barriers to information modelling in socially responsible cities	2019	Sielker, F.
	Facility Management 4.0: BIM und IoT als Grundlage für den Digitalen Zwilling im Gebäudebetrieb	2018	Jaritz, P.
DT and DBL	An openBIM Approach to IoT Integration with Incomplete As-Built Data	2020	Moretti, N. et al
	BIM-based end-of-lifecycle decision making and digital deconstruction: Literature review	2020	Akbarieh, A.
	Total facility management	2021	Atkin, B.

4 Discussion and Findings

The achieved results evidence that the three concepts are approached differently by the scientific community and the degrees of enthusiasm in terms of research are not similar. The novelty of Building Logbook as a research field is clear, and the fact that its definition is already part of recently published reports is found to be helpful to frame the concept meaning as well as its potential realization mitigating, and therefore confusions.

In what relates to Data Templates, the concept is more ancient and it is used for a wide variety of applications. The ISO 23887 definition is not yet commonly known and within the industry it still does not translates the full digitalization potential provided by the standardized metadata structures. Many stakeholders have the impression that Data Templates are documents in .pdf format. To limit the fuzziness of this concept, and despite the ISO definition, the use of the concept Digital Data Templates (DDT), that for some might sound as a pleonasm, can provide in fact and in this moment, the required clarity to highlight the differences and narrow the misunderstandings (Mêda 2020).

The Digital Twin concept is a "hot topic" with growing research in several areas, namely in construction. As mentioned, DT in construction can range several levels and its full potential should be framed. These DT "dimensions" are found to be essential to improve the concept(s) understanding. At this level, recent works as the above mentioned should be assumed as key orientations for this concept future headings.

Before the detailed results discussion, where more than one concept is addressed, it worth's to highlight a pattern concerning the topics or issues addressed around the concepts that constitute the scope of this research. BIM, Asset information management, facility management, as-built or information management are addressed more than once in all the results. While BIM is not surprising, as extensive works have been developed on the last decade, the appearance of management and information, demonstrate a somehow data-driven concern and point to the "feelings" of concepts overlap.

Starting with the concepts that provided more results "Digital Twin" and "Product Data Templates", it is possible to observe that most of the works are related with the Digital Twin strategy in UK or Center for Digital Built Britain, where there is an effort to highlight the "Golden Thread" of information through the construction life-cycle (Watson et al 2019). Other results aim to explore Digital Twins at city scale, where product data template maintain a relevant role. From this, it becomes clear that Data Templates are aligned and are important data sources for the Digital Twins materialization.

Following with the DT concept, the next results to explore are those that derive from its combination with "Building Logbook". Only 3 results were achieved and all are focused on the information delivery during handover to assure improved facility management and life-cycle management for deconstruction. Most concerns are related to the static information that is quite relevant and often incomplete. In this respect, the third result explores incomplete data and the use of IoT both to perform identification and to deal with dynamic data (Moretti et al 2020). The reduced number of results is insufficient to produce strong statements, but it can be mentioned that there is somehow a bond between these concepts and the concerns on how to capture and store different types of data. It will be interesting to follow these developments in a near future.

Finally, the last search results are from the combination of the two base concepts or those identified as enabler's or Digital Twin in Construction boosters; "Building Logbook" and Product Data Templates". There is a single output addressing both concepts and its main objective is to work the problem of information integration from BIM to Facility Management. Using other concepts, the output explores similar issues, as the problems in the exchange of non-geometric BIM data with FM systems. In fact, Data Templates are structures that provide properties or non-geometric data related with products or systems to the BIM model. In addition, the Building Logbook, as mentioned, is a tool with the ability to store and deal with all building relevant data, in which FM data should be included. This means that the problem raised can be solved or attenuated if the information exchange between Product Data Templates and Building Logbook is streamlined (Azmeh 2021).

The developed analysis reveals that, as empirically perceived, there is a strong connection between these concepts. However, research works lack, due to the novelty of some concepts and other research priorities. Future research actions should be initiated with the scope of exploring potential similarities/overlaps between these concepts and considering that some works might address the same issue using different terminology. Despite that, practical heading should be drawn to provide explanations for the stakeholders. At this level, the IDDS Drivers for change, Enablers, Barriers & Opportunities framework was found to be a suitable structure to materialize an analysis on how Digital Data Templates and Digital Building LogBook can contribute to boost Digital Twin Construction. Figure 3 summarizes the main elements identified for each one of the framework parts considering the review and construction trends/strategies.

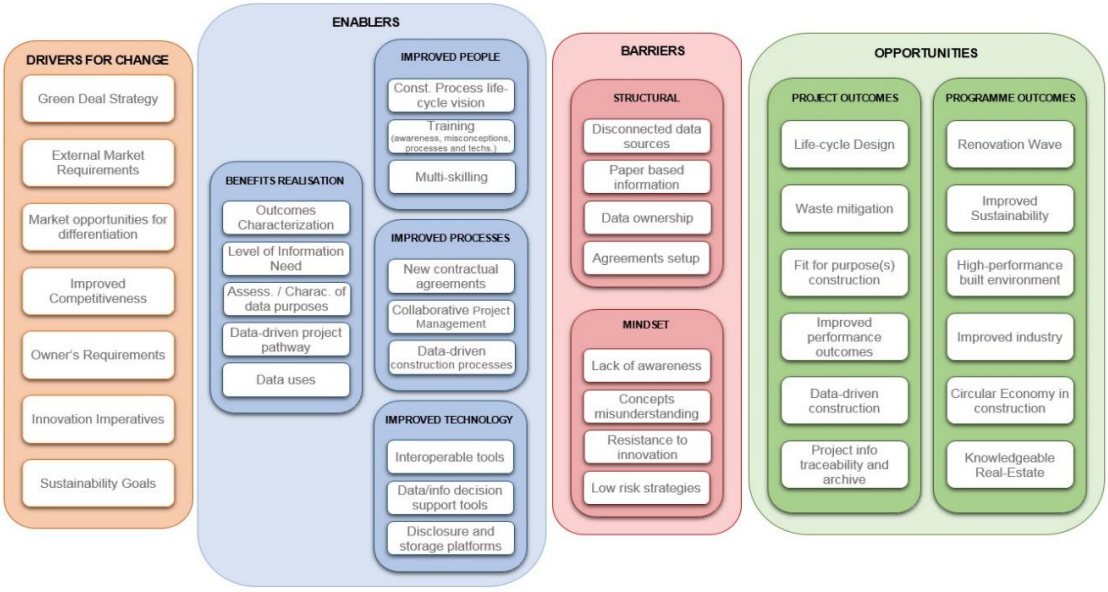

Figure 3. IDDS – Drivers for change, Enablers, Barriers & Opportunities framework applied to Digital Data Templates and Digital Building Logbooks to boost Digital Twin construction at construction entities level.

5 Conclusions

It is unquestionable that over the next years the concepts explored in this research work will reinforce their role within the AECOO sector and across the construction value-chain. Apart from the brands, terminology styling or perspectives, there is the need to raise awareness for its full realization and potential, as part of the actions to raise the industry bar towards a 4.0 vision and sustainability goals. Lack of understanding by stakeholders is not a good sign. As strategic pieces of the digitalization and information strengthening challenges, these concepts must become clearer. In addition, there must be an understanding of their potential synergies, on how do they support each other and how do they can work together, identifying also the overlaps, this is, the information or data exchange requirements/articulation throughout the construction value-chain and entity life-cycle.

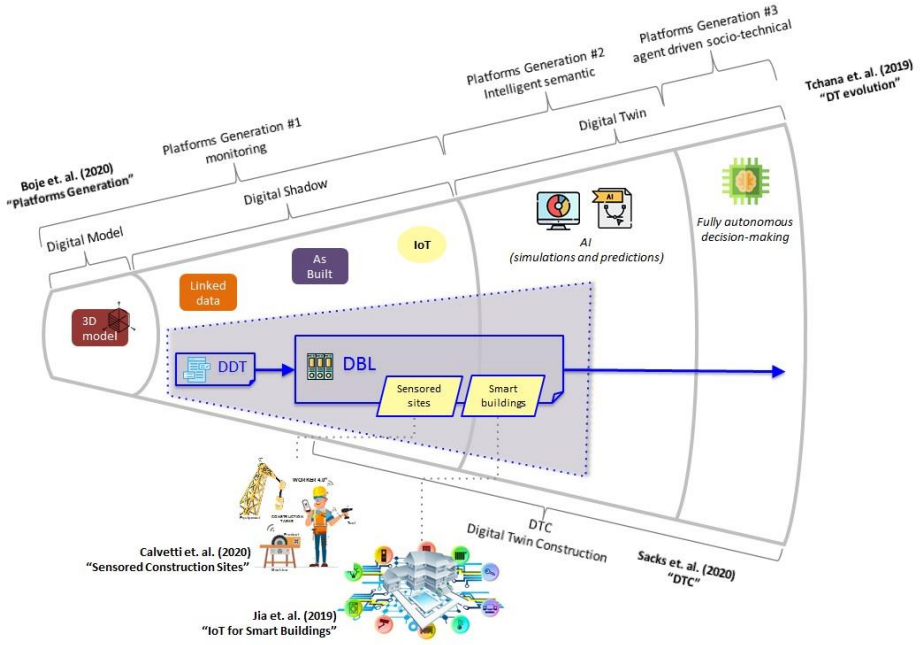

Figure 4. Conceptual framework to boost Digital Twin in construction through the use of Digital Data Templates and Digital Building Logbooks.

As evidenced, the research community as a relevant contribution at this level, as few research results were found with a structured thinking relating more than one of the concepts. To complement the previous section discussion, Figure 4 establishes a conceptualization, framing different dimensions of the Digital Twins and how DBL and DDT overlap, enabling higher DT maturities. At this level, it worth's to highlight that Digital Twin is an evolutionary process (Tchana et al 2019; Boje et al 2020; Fjeld 2020; Sacks et al 2020). In initial phases of the construction process, as the design, a digital model (which currently evolves from 2D to 3D) is developed as a virtual representation of the future physical element (Fjeld 2020). BIM is accomplished when the 3D geometric model is enriched with information about its products/elements. When monitoring the elements with sensors, data collection from the Physical Twin to the Digital Twin begins and higher maturity levels can be achieved (Tchana et al 2019; Boje et al 2020; Fjeld 2020).

This paper aims to start a journey of clarity around these concepts, by being the first to address and conceptualize a common framework considering the three. Future works will continue to disclose and explore, the mission of each concept for the construction industry digitalization and sustainability challenges. The identification of the common information elements, as well as the potential links is an objective to pursuit, namely to measure with more accuracy how these concepts overlap in their contents.

Finally, the development of actions aligned with the elements presented on the IDDS – Drivers for change, Enablers, Barriers & Opportunities framework will contribute to boost Digital Twin Construction at construction entity level, with the adoption of Digital Data Templates and Building Logbooks. Increased understanding of the concepts will switch the focus from choosing the "best" concept, to the importance of integrating all three concepts as a dynamic process. The concepts integration between Data Template, Building Logbook and Digital Twin will highlight synergies which will contribute to boost implementation and innovation across the industry.

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