

Article

Use of KROQI as a Level-2 Common Data Environment in the French Construction Industry

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Abstract: The implementation of a common data environment (CDE) in the construction industry appears to be crucial for organizing and managing the flow of important information within construction projects effectively. However, it is observed that the investments and the costs associated with setting up such environments are often dissuasive, particularly for small- and medium-sized enterprises (SMEs). By launching the Plan BIM 2022 in 2017, the French government aimed to combat the emerging digital divide between large and small construction companies. At the heart of this state-funded plan was the development of a CDE-like collaborative platform called KROQI. The work presented in this article proposes a three-level matrix to characterize common data environments based on computer-supported collaboration work theories. The paper demonstrates how KROQI can be characterized as a level-2 CDE solution. Based on a preliminary study, it explores the perception and satisfaction of practitioners with respect to the features proposed by KROQI. The results show that, among the large variety of features proposed, some are hardly ever used. Therefore, while KROQI appears to be an excellent industry-wide solution aimed at federating initiatives towards digital collaboration centered around BIM models, there is definitely room for improvement.

Keywords: common data environment; collaboration; SME; KROQI; building information modeling



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1. Introduction

The specific context of construction worksites, which are organized around many stakeholders, generates a significant flow of information. In the construction sector, where digitization is on a constant upswing, working methods and tools must adapt to ensure good collaboration and better project performance [1]. In the context of an increasing diffusion of building information modeling (BIM) and construction 4.0 [2], the implementation of common data environments (CDE) in the industry, therefore, appears to be a must in order to organize and effectively manage this information flow within projects [3]. While CDEs have been the subject of numerous theoretical studies [4–7], few research works have been dedicated to providing a holistic CDE analysis framework. Such a framework is, however, necessary to analyze, to characterize, and to compare CDE solutions and platforms in order to provide the practitioners with a helpful decision-making support tool.

On the other hand, the investment and costs associated with setting up a BIM-based CDE can be dissuasive, particularly for small- and medium-sized enterprises (SMEs), which are less financially endowed. In France, in a bid to address the emerging digital divide between large and small construction companies, the government launched the Plan BIM 2022 (PB2022) in 2017, in the context of important initiatives for a better dissemination of BIM at the European level [8,9]. This state-funded plan aims to democratize the use of BIM within the industry, in particular by making digital tools available to French construction companies free of charge. At the core of this plan is the development of a CDE-type collaborative platform called KROQI, which comprises turnkey collaboration tools specifically targeting support for SMEs in their digital transition [9]. The pandemic associated with

COVID-19 has significantly encouraged the use of remote work in construction companies and education institutions [10]. Thus, the use of the KROQI platform has increased considerably, forcing its managers to review the initial free access model. The platform is, therefore, at a crossroads, and an objective analysis of its use would contribute to better decision-making regarding its future direction.

The present research aims to characterize KROQI as a common data environment solution with a view to providing an overview of the overall user satisfaction directly through feedback from practitioners, measuring how the environment is aligned with the needs of the industry, and identifying potential barriers, as well as avenues for improvement. Conducting such an assessment requires the prior definition of an analysis tool that allows to compare the capabilities expected of CDE solutions. Thus, our specific objectives are: (1) to propose a neutral CDE analysis framework, (2) to use the proposed framework to characterize KROQI as a CDE, and (3) to evaluate the feedback of practitioners regarding their use of KROQI.

This work is organized as follows. Based on a literature review, Section 2 proposes a three-level matrix to characterize common data environments and to use the proposed matrix to characterize KROQI as a level-2 CDE solution. Section 3 presents the research approach used to evaluate the user's perception, including the methods and tools used in the online questionnaire and in semi-directive interviews. Section 4 presents the main results, which are discussed in Section 5. Section 6 concludes the article.

2. Characterizing KROQI as a Level-2 Common Data Environment

2.1. Current Definitions of CDE

A common data environment (CDE) is defined by ISO 19650-1:2018 as an “agreed source of information for a project or designated asset, used to collect, manage and disseminate each container of information through a managed process” [11]. A common data environment consists not only of a tool usually referred to as a “CDE solution” but also of a “CDE workflow”. This CDE workflow organizes the flow and management of information throughout the life cycle of an asset. The “CDE solution” is a server- or cloud-based technology incorporating database management, forwarding, issue tracking, and related functions that support CDE workflow [12].

A CDE can be used in a variety of fields and is not unique to construction. It serves as a single source of information for storing, sharing, and managing documents, and encourages parties to use the same systems and platforms to work collaboratively [5]. Project data at different locations and formats can be viewed and downloaded from a single or federated source. The organization can, therefore, interact between project teams and collaborate more effectively, avoiding confusion, omissions, repetitions, and errors [13].

CDE is widely classified as a tool bringing BIM maturity to level 2, where project design outputs are produced in 3D models and are managed by different professional platforms [14].

While there is no general standardized guide for awarding (or not awarding) the CDE qualification, a non-exhaustive list of criteria, which a CDE must meet, can still be established. The PAS1192-2 standard published by the British Standards Institution [14] proposes certain specificities regarding the CDE, particularly with respect to the data structure, by defining four data states:

- WIP (work in progress): data are being created and/or modified, awaiting approval.
- Shared: data are reviewed, shared between collaborators, and can then be used as a reference.
- Published: data have been validated and published.
- Archived: data are no longer current and/or contain important information that may be required in the future.

The PAS1192-2:2013 also mentions a verification procedure between each of these data lifecycle states, indicating that each piece of data must be verified and approved by signature in order to move to the next state. In addition, the WIP workspace must be

specific to each stakeholder group, and the client can only access data with “published” statuses. The modification of a datum must be attributable to an author [14].

Part 2 of ISO 19650:2018 also provides details on the qualification of a CDE. Firstly, it states that the CDE must “meet all the requirements of the project and ensure the collaborative production of information” (International Organization for Standardization, 2018b). In addition, it must allow to assign a unique identifier (ID), based on a previously agreed convention, to each information container. Among other things, the CDE must also, for each data modification, allow the recording of the name of the user who made the revision or modification, as well as the modification date. It must also be possible to control access to each information container [15].

2.2. Characterizing the Use of Common Data Environment in Construction

Although the definitions presented above constitute essential milestones in the understanding of the subject, it would seem that effectively characterizing CDEs to take a theoretical step back towards computer-assisted collaborative work (CSCW) is crucial. Several classifications of CSCW systems have been proposed in the literature [16–18]. The main interest of these classifications is not only to be able to categorize the systems but also to put them in correspondence with particular contexts or needs.

One of the most common classifications used to group CSCW systems is the functional classification. It is known as the groupware functional trefoil [19] as it presents three spaces representing the typical functionalities of groupware: production, coordination, and communication. According to Salber et al., the production space “describes the concepts that motivate group action, which denote the common tangible work, but also the private space of each user as in a single-user system” [19]. For its part, the coordination space defines the dynamics of the actors, their responsibilities, and the temporal relationships between their tasks and activities, while the communication space relates to the mechanisms assisting the sharing of information between the actors.

To more explicitly define what a CDE is, beyond the generalist definition given by ISO 19650 or by PAS1192, the creation of a matrix was deemed essential. This matrix is broken down into 4 orientation axes to describe a CDE platform: the first is document management, followed by coordination, and then communication, and, finally, BIM production. Four levels ranging from 0 to 3 are defined on these different axes. Level 0 is defined as the pre-CDE platform state. Level 1, corresponding to EDM-oriented collaboration, meets the PAS1192 and ISO 19650 standards and is thus considered as the most basic platform. Level 2 corresponds to CDE-centered coordination and presents level 1 functions, as well as additional functionalities, such as communication or document editing, and is called an “advanced level”. CDEs at level 3, corresponding to BIM-centered integration, meet the requirements of level-3 BIM, as defined in the literature [20,21].

The proposed matrix is presented in detail in Figure 1.

2.2.1. Level 0: Pre-CDE

Level 0 corresponds to the pre-CDE level, where no CDE is used. At this level, no platform is set up, and so document management is completed manually. For example, a large part of the documents, plans, and models are printed and then filed in physical format; in some cases, a computer copy is stored within the company. In the absence of dedicated platforms and mechanisms, document coordination remains “ad hoc” at this level. In terms of communication, the traditional means are in place, including e-mail, phone calls, and messaging. BIM models are created and edited using BIM software but are not stored on a dedicated collaborative platform.

Even at the pre-BIM level, file sharing platforms can occasionally be used to transfer BIM files. However, the use of these platforms is not part of a formal policy of the organization.

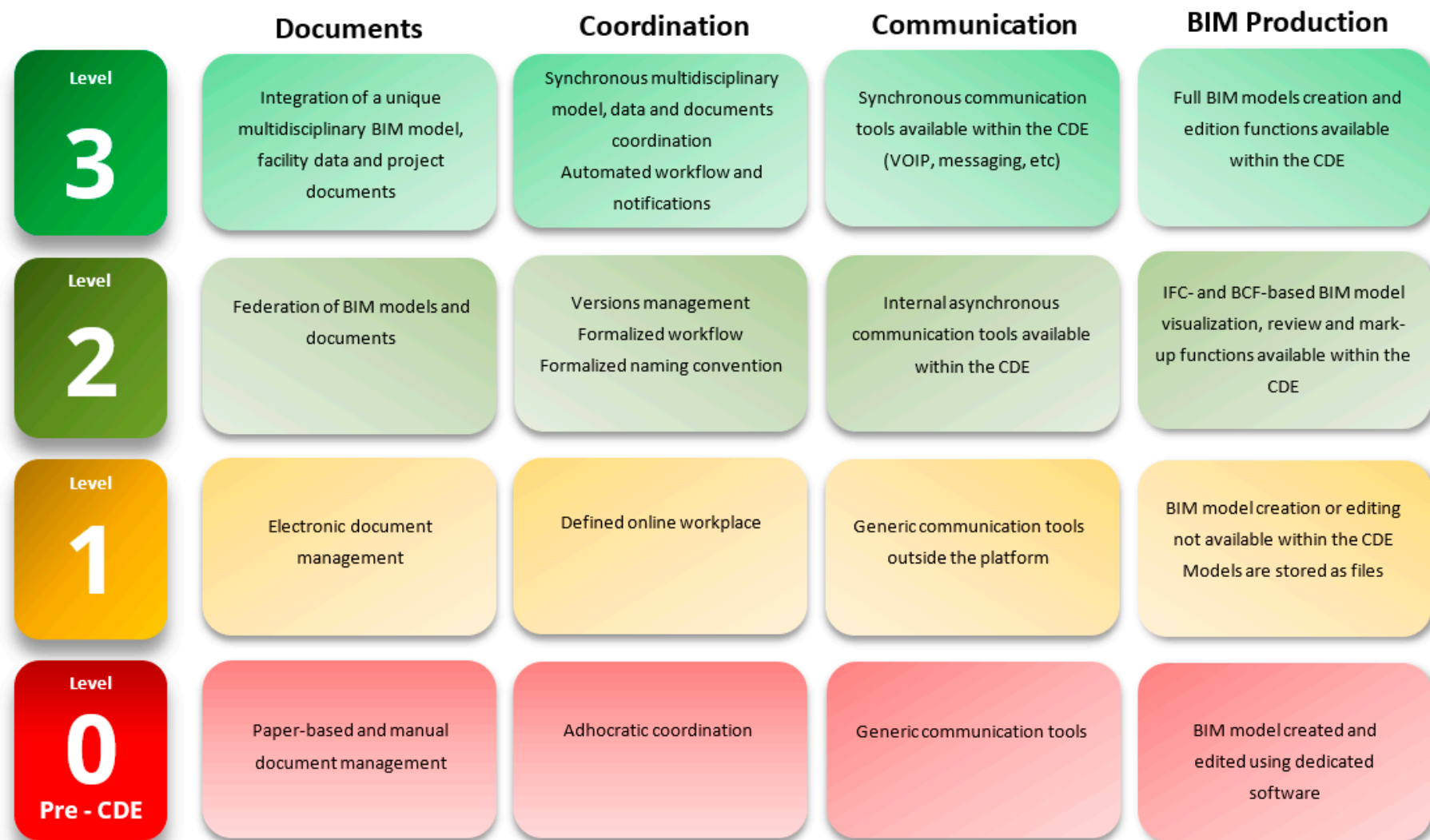


Figure 1. Matrix of the 3 levels of CDE.

2.2.2. Level-1 CDE: EDM-Oriented Collaboration

Level 1 corresponds to electronic document management (EDM)-oriented collaboration. It meets the PAS1192 and ISO 19650 standards and is thus considered as the most basic minimum CDE platform. It is comprised of four main functions, namely document acquisition, classification, storage, and distribution. In addition to these 4 functions, the platform must be secured through access rights and document and user identification in order to guarantee the authenticity and integrity of information and documents. Document acquisition includes the integration of scanned paper documents, electronic documents, such as PDF or office automation files, as well as software work files (cache files) and document exchange. For document classification, indexing by type, by concept, or by keywords facilitates the use of documents. Document storage for its part encompasses the storage medium (storage volume, frequency of consultation, importance of data, and a reduced access time), the organization of the storage, the storage conditions, and the storage location (access according to users' status). The physical location of archives and the storage must be different in order to guarantee preservation in the event of problems, including flooding or fires. Frequent backups reduce risks. Finally, regarding document distribution, an Internet or Intranet connection is necessary.

At level 1, various conventions are implemented according to the management plan and the BIM execution plan. These include a classification convention defining work areas. Each document will thus have its own name and a unique identifier to avoid any confusion or mix-up that each participant must respect. In addition, workspaces will be defined for each company and stakeholder, as well as common areas, such as access to contracts, plans, and models.

In terms of BIM production, BIM models in various formats can be stored on the platform. However, the platform does not offer functionalities for creating or editing such models. For that, the files must be downloaded, edited in the creation software, and then uploaded once the creation or modification is complete.

At this level, the communication mechanisms are external to the platform.

2.2.3. Level-2 CDE: CDE-Centered Coordination

At level 2, the focus is on federating project BIM models, data, and documents. Here, the platform's ability to link models and documents in order to update information automatically provides time savings and a guarantee of information. If a change is made to a piece of data, it is reflected in all the associated files. For example, if the thickness of the walls is changed in one model, it is also changed in all the associated models and, potentially, in all the federated documents.

At this level, it is important to have a version control system, i.e., a process that integrates the electronic "signatures" of verifiers and allows follow-ups of the process. Thus, during the verification of a document, verifiers have a limited amount of time to issue a notice of complete or partial approval or refusal. For a document to be released for distribution, it must be approved in its entirety by all reviewers. In addition, durations are set in the BIM management plan in order to formalize the workflow. Furthermore, a schedule with various milestones can be put in place in order to optimize the work according to the criteria defined in the management plan. Finally, each model must allow multidisciplinary coordination (including 3D coordination). Indeed, the models must have the capacity to be assembled to form a more complete model that can allow a collision analysis or 4D assemblies.

Still at this level, an asynchronous communication system, such as instant messaging, must be integrated in order to allow rapid and archived exchanges. Moreover, the exchange formats, such as BCF formats, must be formalized by the BIM management plan and recalled in the BEP. This allows compatibility with various software formats without too much information degradation. The automation of certain tasks is all the more crucial as it provides significant time savings, such as in the calculations of lowering loads, for example.

Here as well, the possibility of carrying out certain model editing tasks should be considered within the platform. This means that model modifications then become possible, but these will only be simple tasks requiring simple computing power. For example, the architectural drawing options must be possible, but the calculation options must be carried out on a fixed machine.

2.2.4. Level-3 CDE: BIM-Centered Integration

Level 3 illustrates the importance of a single multidisciplinary model containing all the information and linked with all the documentation of the project. Thus, there is a central model containing several disciplinary models, such as the architecture, the structure model, the HVAC, etc. Moreover, additional divisions can be conducted by zone, thus multiplying the number of sub-models.

At level 3, synchronous coordination is crucial because, in its absence, the modeling progress is significantly slowed down as only one person can modify the file. It becomes possible to conduct simultaneous and concurrent modeling on the same shared model. In addition, the concurrent modeling makes it possible to more quickly realize 3D coordination, including clashes and collisions detection.

At level 3, the CDE includes a communication system allowing instant messaging and/or other synchronous communication tools. Indeed, communication can be via VOIP or video, so, in the event of a problem, it is thus easy to understand and explain what is wrong.

At level 3, by the principle of the single model and the synchronous connection, the use of the sub-models becomes very interesting. Documents can also be edited within the platform in order to maximize the centralization of information.

2.3. The KROQI Platform

2.3.1. Background

The KROQI platform, developed by the Scientific and Technical Centre for Building (CSTB), is presented as a tool for exchange and collaboration for companies in the sector. Freely accessible and easy to use, it is compatible and interoperable with many business software applications, offering storage, management, sharing, and data verification functionalities to all actors wishing to understand BIM.

KROQI aims to support SMEs in particular in their digital transition as they tackle the digital divide between large and small companies. While the platform is mainly aimed at construction SMEs, it targets a wide category of stakeholders, including “construction and development professionals, project owners, contractors, design offices, architects, structural or finishing companies, technical inspectors, insurers, and more” (Plan BIM 2022, 2022). The platform can be downloaded directly from its website (<https://kroqi.fr>, accessed on 22 October 2021), where it also offers tutorial-type explanatory videos to present its operation, as well as a question forum.

On 24 June 2021, during the BIM World Forum in Paris, it was announced that the platform had accumulated 100,000 users, including more than 20,000 who connected on a regular basis.

2.3.2. Positioning KROQI as a Level-2 CDE

According to article 1 of the general conditions of use of the platform, the collaborative suite integrated into the KROQI platform has an electronic document management (EDM) service providing the KROQI platform with a user interface, project data hosting and sharing between workspace users, and rights management within the workspace.

KROQI includes an instant chat tool called Chat, as well as a video conferencing tool called AirTime. It also offers a tool known as KROQI Drive that allows the automatic synchronization of local files on the platform. KROQI is also linked to the EveBIM model viewer. The EveBIM software is also developed by the CSTB and, therefore, allows the visualization of digital models, the exploitation of the information they contain, and their

enrichment [22]. In terms of the coordination of activities, the platform offers its own shared management electronic diary, a task manager, and a validation monitoring system. These functionalities of the KROQI ecosystem are linked together in a bid to secure efficiency and ease of use.

The user profiles hierarchy and the access rights management allow to define projects to which different profiles have access, as recommended by part 2 of ISO19650:2018 for CDEs. KROQI also identifies the data structure in four states/statuses, namely ‘work in progress’, ‘shared’, ‘published’, and ‘archived’ (PASS1192-2:2013). Moreover, in order to ensure the privacy and integrity of exchanges and data, KROQI uses “digital certificates based on SSL technology” and states that these certificates “allow data to be encrypted during exchanges [. . .]. The data storage is distributed over two datacenters located in France and managed by the French host Scaleway” [23].

By crossing the description of the functionalities in the platform with the above-mentioned CDE criteria established by the PASS1192 and the ISO19650, KROQI may be considered as a common data environment. Moreover, from its description, KROQI even rises to a level-2 CDE according to all the axes of the matrix presented above. Specifically, it allows:

- a federation of models and project documents on the platform;
- the possibility of having version management, formalized workflow, multidisciplinary coordination;
- the existence of asynchronous communication and integrated communication tools; and
- the availability of BIM model visualization, review, and mark-up functions within the platform.

3. Research Approach

With KROQI characterized as a level-2 CDE, it is interesting to have an overview of users’ perceptions of the features offered in order to identify areas for improvement as they pertain to the needs of practitioners. An online questionnaire was set up to provide quantitative and qualitative data on the subject. Moreover, two semi-structured interviews with platform users were recorded to further explore the qualitative aspect of the research.

3.1. Online Questionnaire

Murray and Fisher [24] state that an online survey is the best way to collect information from highly qualified business professionals without disrupting their work. It is this approach that was, therefore, adopted here, with the online survey tool LimeSurvey chosen. The steps in the process were: (1) carry out a literature review to prepare questions; (2) identify issues; (3) test and modify questions if necessary; (4) distribute the survey online; (5) collect responses; and, finally, (6) analyze the data.

The questionnaire design method was based on the Survey Methods and Practices document [25]. The questionnaire is composed of several types of questions, namely open, unopened, multiple choice, or single choice. There were many open-ended questions, chosen mainly so as not to influence respondents and to thus correctly assess their perception. Moreover, care was taken to add an optional comment box to most of the questions, which left as much room as possible for respondents to express themselves. The questionnaire also contained Likert scale questions, where the meaning of the scale is always specified. The questionnaire has 43 questions in total and can be completed in 15 to 20 min voluntarily and anonymously.

The survey was distributed as an open link to professionals from French construction companies, who were the target users, and sharing was encouraged. After the responses were collected, the data were then exported from LimeSurvey to Microsoft Excel, where they were then formatted for use, specifically through a design of dynamic tables and graphs that are updated as data are added with the progression of the survey.

A total of 39 responses were received. A response was counted if the respondent had answered at least one question outside the first part.

3.2. Semi-Structured Interviews

The distribution of the online survey was accompanied by a request for a voluntary interview, where the respondent could indicate whether he or she was potentially in favor of being contacted again for further information and/or clarifications, and this request could be made in the final part of the online survey called “Authorizations”. We were, therefore, able to select two voluntary participants for a semi-directed interview in order to complete the results obtained in the quantitative survey. The selection of the two interviewees was based on their good experience with the KROQI platform but also on their significant professional experience. To ensure good representativity, it has been decided to select two complementary profiles: a work supervisor with more than 10 years of experience and an operation manager with 4 years of professional experience.

To maintain anonymity and for simplification, we will refer to them below using the male form and by coding them arbitrarily as Participant A and Participant B. The two profiles are summarized in Table 1 below:

Table 1. Presentation of the participants in the semi-structured interviews.

	Participant A	Participant B
Position	Operations Manager	Work supervisor
Professional experience	4 years	11 years
Start of KROQI use	October 2019	April 2019

Due to the restrictions imposed by the COVID-19 pandemic, the two interviews took place remotely, via a video-conference call on the Zoom platform for Participant A and via a telephone call for Participant B. The calls were scheduled to match the availability of the two participants, and each lasted between 30 and 45 min.

Although the thread of the discussions was left to the respondents as much as possible, with minimal interruptions, the discourse was still partly oriented around various themes defined beforehand. These areas, summarized in an interview guide, include the expectations and uses of the KROQI platform within the company, the feeling and satisfaction of the participant vis-à-vis the platform, future use, areas for improvement, and how to bring KROQI closer to the needs of the participant and the company.

4. Main Results

4.1. Profile of the Respondents

The respondents were also allowed to indicate more than one answer regarding the positions they held within their companies. Engineers were the most represented (28%), followed by architects (18%) and work supervisors (18%). The positions of manager (14%), coordinator (7%), site manager (6%), director (3%), and master journeyman (3%) were also represented. We also note the presence of apprentices and/or trainees (12%).

Respondents with between 10 and 20 years of construction experience were the most represented (32%), followed by those with between 5 and 10 (27%), and then 1 and 5 (18%). Only one respondent indicated having between 20 and 30 years of experience in the field, and the same was true for the ‘30 years and over’ category. We also noted that 13% of respondents were quite new to the construction industry, with less than a year of experience.

A large majority of respondents (64%), regarding the question “Are you familiar with the concept of a ‘collaborative platform?’”, indicated having an idea of what it meant, while no respondent was an expert in the field. Further, 18% of the participants said they had heard of it without really knowing what it meant, and 18% also said they had never heard of it. Further, 45% of the respondents indicated that they had already worked with a collaborative platform before KROQI, 18% indicated that KROQI was their first collaborative platform, and 37% said they did not know. In the comment space where they were asked to indicate the names of any other platforms, the following answers

were provided: “Google Drive/OneDrive”, “Microsoft tools”, “Revit”, “WhatsApp and messaging”. Moreover, an equal percentage of participants indicated that they were familiar with the concept of common data environments and that they did not know its meaning.

4.2. Usage of KROQI

While a large percentage (27%) indicated that they did not know when their company started using the KROQI platform, a majority (33%) identified the period from January to June 2020 as corresponding to the period of implementation. The periods January–June 2019, July–December 2019, and July–December 2021 represented 20%, 13%, and 7% of the responses, respectively.

In addition, 67% of the respondents indicated the free aspect as being, to their knowledge, a determining factor that led their companies to implement KROQI. Other factors included the need to digitize processes, indicated by 40% of the respondents. Ease of access (27%), the need for coordination tools (27%), the need for cooperation tools (20%), external recommendations (13%), the need for communication tools (13%), the PB2022 campaign (6%), contractual demands (6%), or even a process of eliminating paper (6%) were also factors indicated as having led respondents to KROQI. Regarding the training of respondents to the use of KROQI, 36% indicated that they had not received any training, while 36% indicated they had received self-training, and 21% internal training. No external training was observed among the respondents.

A majority of the respondents (67%) indicated that they used KROQI’s Chat instant messaging, while none of the 15 respondents to this question indicated that they used the AirTime video conferencing tool integrated into the platform (Figure 2). In the comments, tools such as ‘Zoom’ or ‘Facetime’ are particularly indicated as being used in substitution to Airtime. In addition to KROQI messaging, several respondents (20%) indicated that they still mainly used emails and mobile phones.

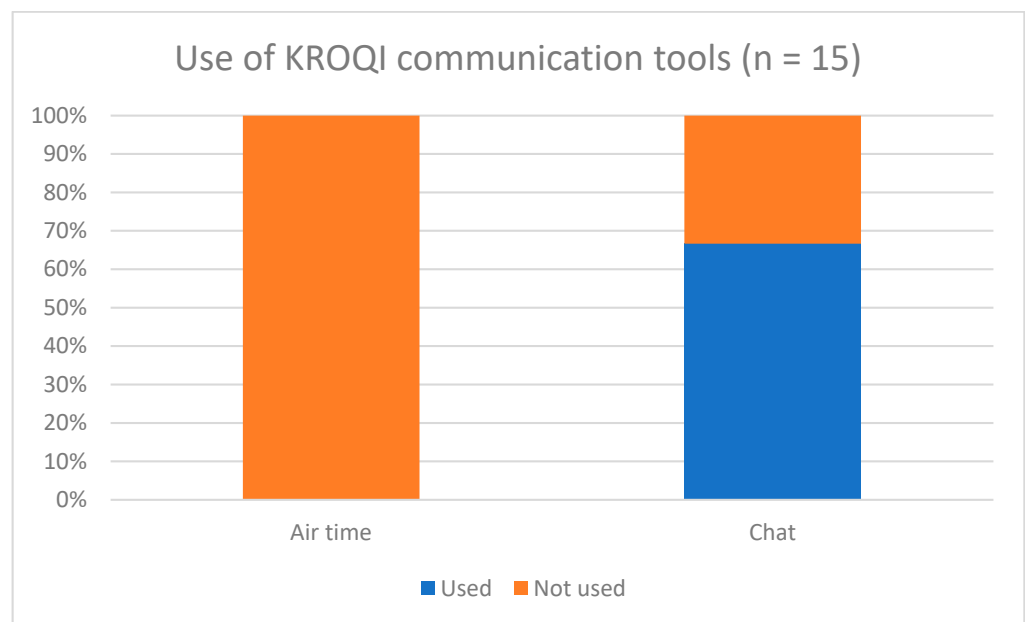


Figure 2. Use of KROQI communication tools.

The respondents were asked for an assessment of their satisfaction with the communication tools using a Likert scale offering the options ‘very satisfied’, ‘rather satisfied’, ‘neutral’, ‘rather dissatisfied’, and ‘very dissatisfied’. Regarding the AirTime videoconferencing tool, half of the participants who answered this question indicated that they were very dissatisfied, a quarter indicated that they were rather dissatisfied, and the last quarter was neutral (Figure 3). For the Chat instant messaging, a majority (44%) said they were quite satisfied, 33% were neutral, and 22% said they were quite dissatisfied.

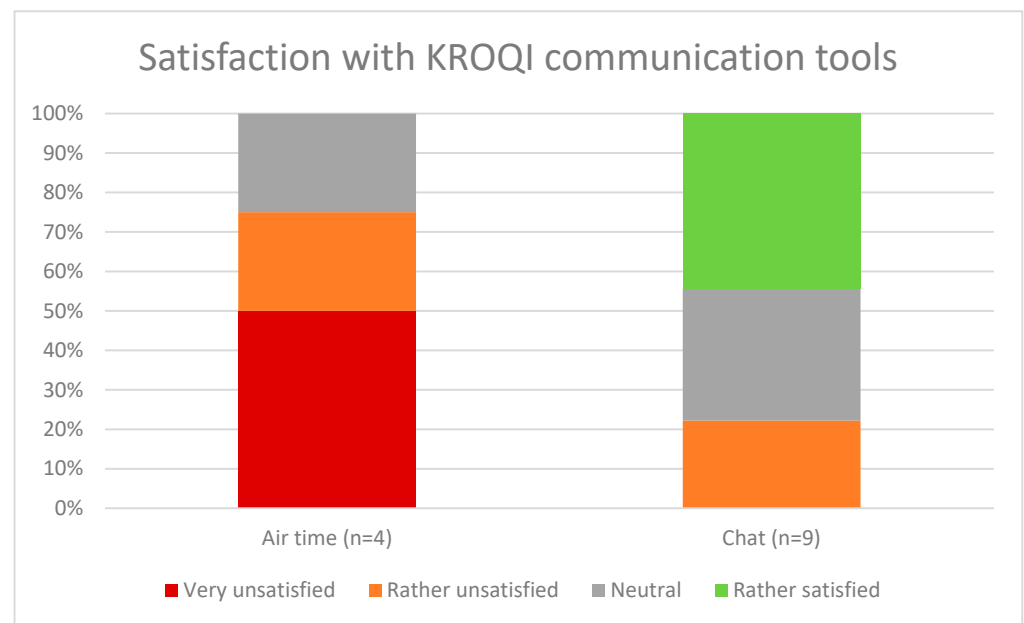


Figure 3. Satisfaction with KROQI communication tools.

The coordination tools, consisting of the platform’s electronic diary, the task manager, and the validation system, were used by a large majority (73%) of respondents (Figure 4).

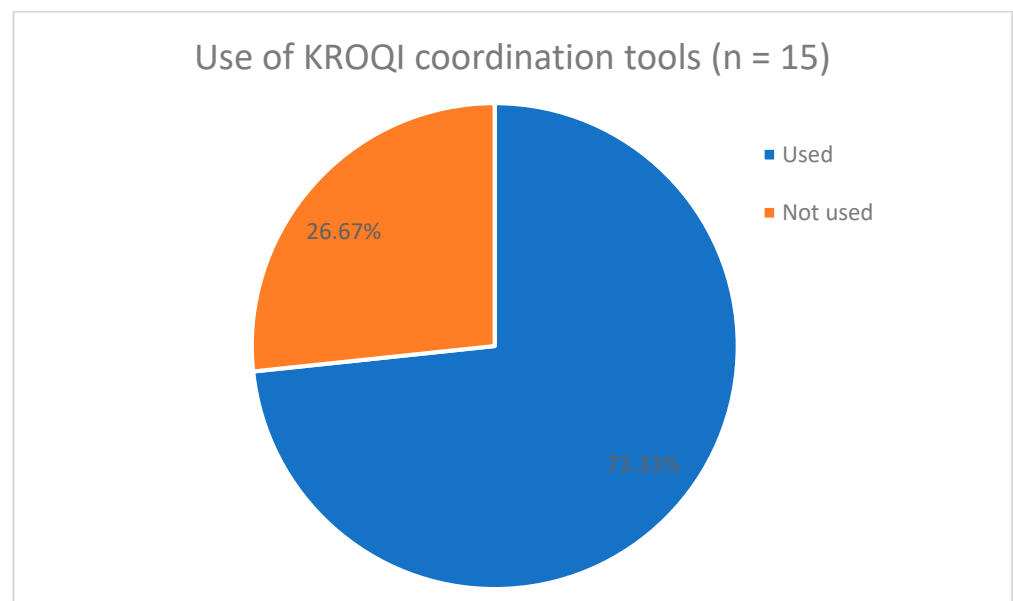


Figure 4. Use of KROQI coordination tools.

The respondents were generally enthusiastic about the Agenda tool (Figure 5). The rather satisfied (40%) and very satisfied (10%) rates associated with Agenda were much higher than those for the Tasks and Approvals tools (rather satisfied (13%), very satisfied (0%)). Regarding the Tasks tool, half of the respondents indicated neutral satisfaction, and 38% indicated being rather dissatisfied. The Validations tool obtained a higher rate (38%) of very dissatisfied responses.

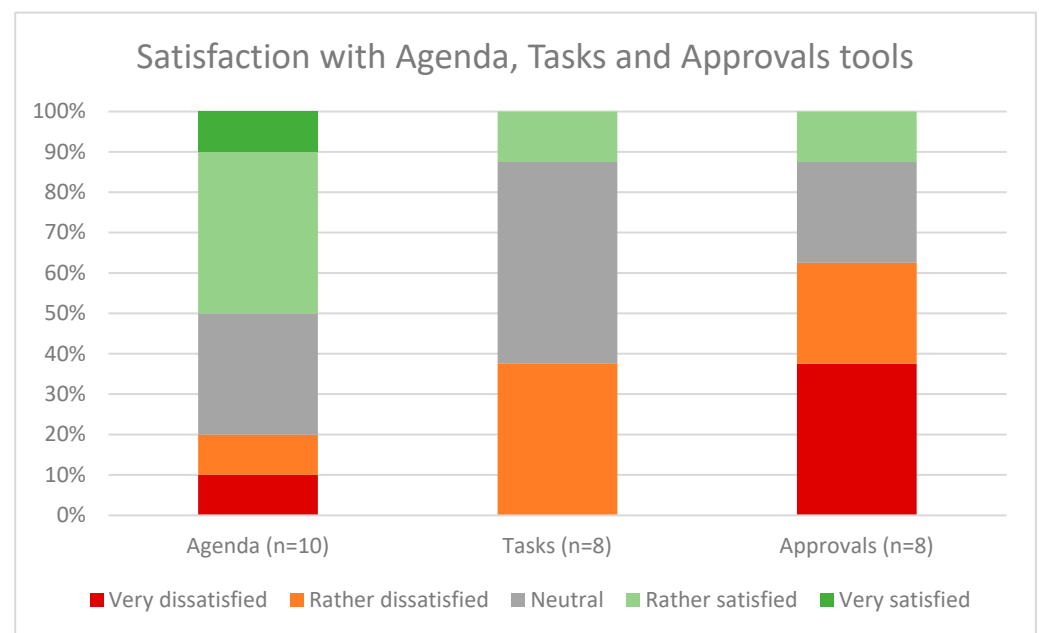


Figure 5. Satisfaction with Agenda, Tasks, and Approvals tools.

Regarding cooperation tools, seven out of ten respondents indicated that they did not use KROQI Drive, and nine out of ten respondents did not use EveBIM (Figure 6).

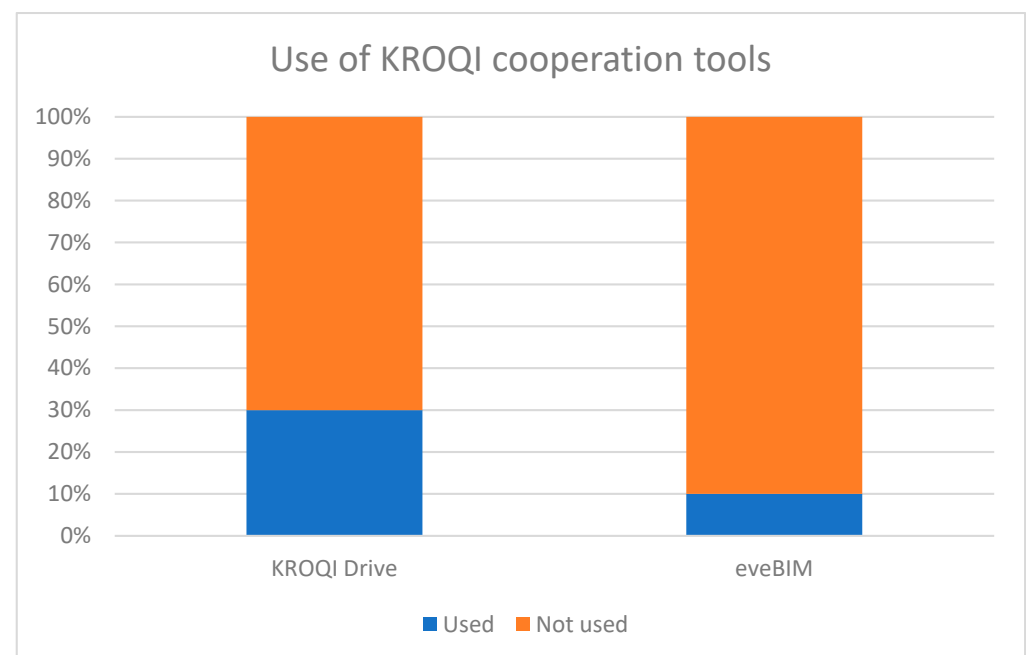


Figure 6. Use of KROQI cooperation tools.

The participants who answered the satisfaction question on EveBIM were split between 'neutral' and 'rather satisfied'. Regarding the KROQI Drive, a majority (60%) was 'neutral', followed by (10%) 'rather satisfied' and (10%) 'rather dissatisfied' (Figure 7).

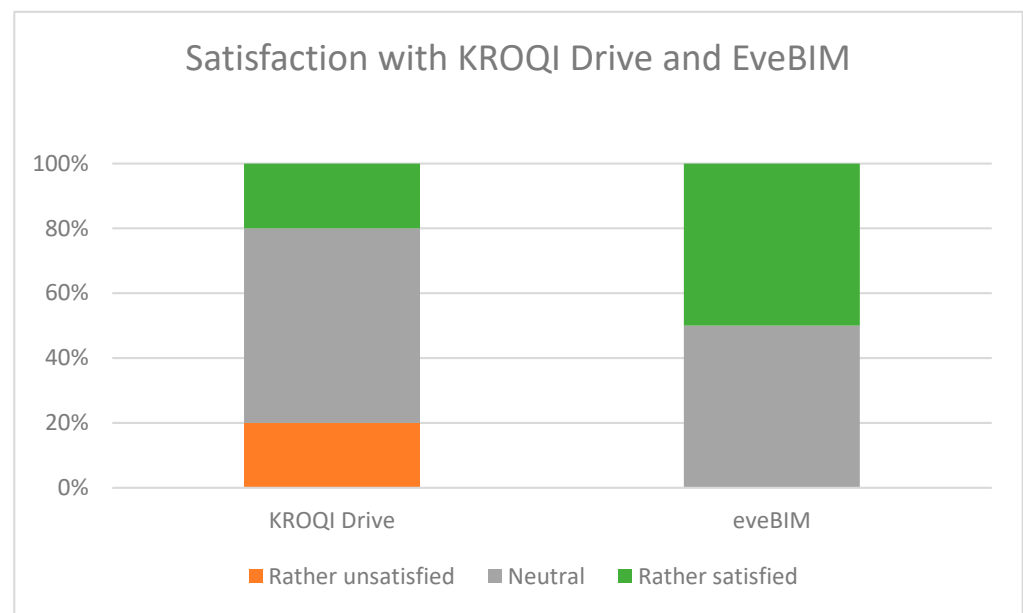


Figure 7. Satisfaction with KROQI Drive and EveBIM.

5. Lessons Learned and Discussion

While it is difficult to generalize the conclusions of the present study due to the limited number of respondents, this paper presents some interesting elements of discussion.

5.1. Perception and Adoption

While the KROQI users interviewed here have a wide variety of areas of expertise within the construction industry, their businesses are almost exclusively SMEs. The intention of the PB2022 to address the smallest construction companies seems appropriate and respected in practice. Among the users surveyed, a clear peak in traffic can be observed on the platform following the global COVID-19 pandemic, with a majority of the respondents having implemented the use of KROQI during this period. Furthermore, while the need to digitize processes is widely cited as a factor that led to the creation of KROQI, the free character of the platform appears to be the most important factor. This importance was also confirmed by the participants in the semi-directed interviews.

The respondents were not BIM experts, and, while some said they had some experience in the field of collaborative platforms, most of the tools cited as examples did not really qualify as such. Nevertheless, the benefits of the digital transition and the digitization of processes were widely recognized by the participants. Resistance to change, with regard to the use of new technologies, was not felt here, which is ultimately not surprising because, when dealing with users of the CDE platform, we are addressing professionals who are a priori convinced of the benefits of digitization.

On the other hand, the responses were more mixed with regard to the proposed solutions provided by KROQI to the needs of companies. Indeed, we can already see that, among all the users questioned, none used all the tools of the platform. Communication and cooperation tools are largely neglected compared to coordination tools. The turnkey aspect of the platform does not, therefore, appear to be a success, and this is explained in particular by the presence of several barriers.

5.2. The Barriers

Many of the barriers encountered could be described as technical barriers. The barriers are first observed in the communication tools, which are the tools that are least used by the users questioned, particularly the videoconferencing tool. Indeed, a respondent already told us that screen sharing is not functional on AirTime, and that “the number of participants is limited to a small number”. In addition, he specified that the tool “does not

allow to invite a person not registered on the workspace”, which does not allow to extend any use outside the internal space if the other stakeholders are not on KROQI.

Technical barriers are also observed in the coordination and management of documentation. Participant B indicates that co-editing files on the platform was not available to him until the end of 2020. In addition, some tools were still in development in 2021, and interview participants also regretted that they still did not have a functional KROQI application. Of note, the application was already in planning when they implemented the platform in their business processes. This lack of a mobile application is also reflected in the comments of some survey respondents.

While the work tree structure was appreciated by the participants, the limitation of the management of the storage space was decried, particularly by a respondent indicating that “the size of the files supported by KROQI cannot exceed 2 GB”. Moreover, this storage space limitation does not get better with the establishment of the free perimeter. Participant A regretted the “limits set, in particular storage, [which] are much lower than previous ceilings”, while his company linked its processes on KROQI based on the initial promises.

The announcement of the modification of gratuity of the service also led to “skepticism on the part of subcontractors”, and respondents also deplore this management. Participant A would have particularly wanted announcements concerning the end of the free period to be visible only to the administrators and not to guests, which, according to him, would have avoided a certain panic and skepticism towards KROQI among the subcontractors.

These communication faults echo the low satisfaction of respondents with the support provided by KROQI. This was especially true of the forum, which received a large majority of negative reviews. Commenting on the survey, a participant regretted that the KROQI forum has gone to read-only mode since the announcement of the end of free access, and he even denounced “censorship”.

Internet connectivity on construction sites was also mentioned, but this problem is not specific to KROQI but rather relates to one of the notable barriers to the use of CDEs.

6. Conclusions

The work presented in this article proposes some interesting contributions to efforts to align common data environments to the real needs of practitioners in the construction industry while presenting some limitations to be addressed in future works.

The first significant contribution is the three-level matrix proposed to characterize common data environments. The matrix relies on computer-supported collaboration work theories so as to integrate both the expected groupware components and the essential BIM needs. Notwithstanding the fact that the matrix can be improved and requires subsequent validation, it constitutes an important milestone towards the definition of a common framework for the analysis of existing and future systems. The second contribution of the paper is related to the characterization of KROQI and a preliminary study of the perception of a sample of current users of the platform. Research shows how KROQI can be considered as a level-2 CDE, and, among the variety of features proposed, some seem to be hardly used at all, while others do provide full satisfaction. There is, therefore, room for improvement, even though KROQI appears to be an excellent industry-wide project to federate initiatives towards digital collaboration centered around BIM models.

The work presents a certain number of limits that it is important to present here in order to ensure a better appreciation of the results. First, the main limitation concerns the number of respondents to the online questionnaire. While the 39 responses received constitute a reasonable number, a larger number would have given even more meaning to the results of the study and would undoubtedly have contributed to further consolidating the quantitative aspect of the results. Another limitation of the work is related to the validation of the matrix proposed for the analysis of the CDEs. Even though it was built with an iterative approach, the matrix in its current version still requires additional thorough validation to assess not only its content but also, and above all, its ability to allow the effective analysis of all types of existing CDE platforms.

Future works will consolidate the proposed three-level matrix through large-scale experimentation while proposing a comparative analysis of the existing CDE platforms. Such a comparison could provide a good understanding of the best practices and provide room for cross-pollination between the different initiatives. Some visualizations will also be developed to better illustrate the integration of BIM aspects in the proposed matrix. Future works will also conduct further investigations on the use of KROQI, including the benefits provided by the platform in terms of money and time.

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