Technology's Dual Role in Challenging and Supporting OSH and VDC Professionals[1]

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ABSTRACT

In this study, we examine how occupational safety and health (OSH) professionals and virtual design and construction (VDC) professionals navigate the use of technology for OSH purposes and how the interdisciplinarity between the two professions affects their occupational identities. Through a positioning analysis of interviews with OSH and VDC professionals, we conclude that the use of technology both challenges and supports the identity of OSH professionals. Technology enhances collaborative and alliance building aspects of OSH professionals' identity; however, it is in risk of replacing dialogue, a core aspect of OSH professionals' work. We find that cooperation between the two groups may enhance VDC professionals' identity, as it allows them to exude collaborative competencies. Interdisciplinarity is a fruitful path for enhancing the use of technologies for OSH purposes, but the conservative nature of the construction industry poses a challenge to this.

KEYWORDS

construction / occupational identity / occupational safety and health / technology / virtual design and construction / VDC

1. Introduction

It is a well-known problem that occupational safety and health (OSH) in the construction industry is severely challenged with both psychosocial issues (Lingard 2019) and a high risk of accidents and musculoskeletal disorders (Lingard 2013). However, as the use of technologies and virtual design and construction (VDC) has revolutionized the industry and keeps expanding (Baptista et al. 2020; Kunz & Fischer 2020; Rezgui et al. 2009), several studies have pointed to the use of technologies as a way to enhance OSH (Afzal et al. 2021; Ajslev & Nimb 2022; Babalola et al. 2023; Shafiq & Afzal 2020).

In construction, OSH professionals play a vital role in the improvement of OSH (Møller et al. 2021; Spangenberg 2009). As technology continues to develop and present opportunities for improving OSH of the construction industry, there is a clear need for OSH professionals to be oriented toward technology. This is backed up by previous

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research pointing to the vital importance of OSH professionals continually developing their technology competencies (Holden & Vassie 2010) and ability to challenge current OSH practices (Provan et al. 2017).

However, OSH professionals' development of new competencies and challenge of current practices may be difficult. Le Coze (2024) has described this issue as a 'middle-life crisis' within the OSH profession, which refers to a lack of integration of new practices and principles. OSH professionals must take advantage of available knowledge to move beyond irrelevant practices in their work, which is also a major contributor to their discontent with their job. Therefore, introduction of technology into the OSH profession may pose an opportunity to move beyond current practices.

Additionally, an OSH professional's role is already quite diverse and includes many different aspects. In the Danish construction industry, OSH coordinators largely fill the role of OSH professionals. The OSH coordinators are required to complete a one-week training course. Other than this, OSH professionals in the construction industry have no particular requirements but are typically in charge of ensuring compliance with national OSH law, doing safety rounds and risk assessments on construction sites (Ajslev & Møller 2023). In general, OSH professionals have been described as searching for a common profession in particular and may claim several different occupational identities, as their educational background, specific tasks, and association with workplaces are quite varied (Uhrenholdt Madsen et al. 2019). This affects how OSH professionals are typically met, as their role may not be understood and therefore not valued (Provan & Pryor 2019). Also, the fact that organizations often perceive the employment of OSH professionals as an expense rather than an investment is associated with a general lack of acknowledgment of OSH (EU-OSHA 2024) – meaning OSH professionals may be perceived negatively.

For people working with technology within construction, such as designers and engineers, several studies find that only few of them use technologies for OSH purposes, as they are rarely asked to take OSH into consideration and implementation and adaptation of technology is often limited or slow (Alomari et al. 2017; Bong et al. 2015; Che Ibrahim & Belayutham 2020). As use of technology expands in the construction industry, the role of a VDC professional has emerged. VDC professionals are expected to have technical knowledge and have a variety of tasks, such as clash detection, managing VDC requirements, simulate work preparation, and visualize models. Like the OSH professional, the role of a VDC professional is not clearly defined (Gustafsson et al. 2015).

As the construction industry develops and use of technology expands, it is vital for OSH professionals to consider how technology can improve their work of enhancing OSH practices in the construction industry and to develop competencies in applying technologies for OSH purposes. These skills may also be important VDC professionals to cultivate, as their expertise in technology can be beneficial for advancing OSH in construction. This interdisciplinarity may be challenged, as OSH professionals already face challenges of not being acknowledged for their work and the difficulty in introducing new practices.

In this article, we examine the professional identities of OSH and VDC professionals as well as how interdisciplinarity between these two fields influence their professional identities. Additionally, we investigate how an interdisciplinary approach may enhance utilization of technology for OSH purposes as well as industry-related challenges posed to this purpose.

2. Methods

2.1 Terminology: VDC and technology

In this study, we asked the interviewees about VDC and technology and found that these terms may refer to a broad range of concepts. When it comes to technologies, several interviewees mentioned Dalux, a program for managing files and communicating. The program allows several people to gain access to relevant information. Dalux also has a building information modeling (BIM) –viewer, which makes it possible to see 2D, 3D, and 4D models of building projects and to take pictures and connect them with specific tasks.

In the literature, VDC does not refer to a specific technology or a set of technologies but rather a structured model or approach to meet project objectives through the use of technology, which can transform communication and visualization for construction projects (Kunz & Fischer 2020). While this may be the case, we found that interviewees in this study often used VDC to refer to a general use of technologies, including Dalux, rather than presenting a structured approach to meet project objectives through the use of technologies. In addition, interviewees mostly used the term VDC interchangeably with digital technology or technologies. We will use the term VDC more similarly to the interviewees, as a broad term for digital technologies, in order to draw upon their context in our analysis. Additionally, the term VDC professionals is used, as the interviewees use this term. However, the literature also uses this term (Ajslev & Nimb 2022; Gustafsson et al. 2015).

This use of the term VDC draws on an emic approach (although some studies have used the approach in a more extensive way), where the researcher adopts an 'insider' understanding (Brown et al. 2020). This approach comes with a number of advantages such as understanding a phenomenon from the point of view of respondents thereby allowing the researcher to avoid an interpretation based on the researcher's own beliefs. Adopting an approach inspired by an emic perspective, this study will avoid confusion on terminology in the analysis, as the interviewees' understanding of VDC does not fully align with the theoretical understanding hereof. While an argument could be made for an etic approach that is closer to the theoretical understanding of VDC, by adopting the interviewees' understanding of VDC, the study is able to gain a deeper understanding of how technologies are actually used in practice. It is however important to note that this use of VDC only partially resembles the theoretical understanding, as described by Kunz and Fischer (2020).

2.2 Cases

This study's analyses are based on case studies conducted in three large construction companies in Denmark (with 1500+ employees). In each of the three cases, we conducted interviews with VDC professionals (responsible for or work with digital technologies or VDC in the specific company) and OSH professionals as well as VDC managers and OSH managers within the companies. All three case companies are among leading contractors in Denmark, with departments dedicated to both OSH and VDC. These companies are considered to be at the forefront in terms of both VDC and OSH in the Danish construction industry – best-case companies (Flyvbjerg 2006). This suggests that findings in the analysis likely represent some of the most developed current practices with implementation of VDC and its use for OSH purposes, and the best possible

integration between VDC and OSH, including mutual understanding between VDC and OSH professionals.

The cases were recruited via the research group's network, involving OSH professionals from the participating companies. At the time of recruitment in 2019, VDC technologies were not as commonly used as they are now. As a result, it was essential to select companies of a sufficient size actively investing in this area in order to study processes associated with using VDC for OSH purposes.

2.3 Interviews

The study was conducted as an interview-based study, informed by existing research as well as preliminary and ongoing observations in the cases. However, this was not possible in case 1, which was conducted through online interviews due to COVID-19. In cases 2 and 3, researchers followed the work on a single construction site in each case, initially shadowing (Czarniawska 2007) an OSH professional. Through this, the researcher became familiar with other stakeholders and was able to observe practices related to VDC and OSH, as well as recruit VDC professionals and OSH professionals for interviews. The main purpose of observations for this study was to inform the interviews and recruit interviewees. Therefore, the observations have not been analyzed.

The interviews followed a semi-structured format (Brinkmann & Tanggaard 2015), focusing on the interviewees' roles, their collaboration within the company and the project, the technologies they use in their work, their expectations for new technologies, and the changes these technologies have brought about. Additional questions addressed the implementation of new technologies, their impact, and how they are currently, potentially, or expected to be used for OSH. The interviews also explored barriers and opportunities associated with integrating these technologies for OSH purposes.

The interviews were distributed as shown in Table 1. In total, 23 interviews were conducted, six being with managers. Sixteen of the interviewees were male, seven were female. Background information about the interviewees can be seen in Table 2.

Table 1 Distribution of interviews

Cases	Number of interviews pr. case	Distribution of interviews
Case 1	8	*4* with OSH professionals *1* with an OSH manager *2* with VDC professionals *1* with a VDC manager
Case 2	8	*5* with OSH professionals *2* with VDC professionals *1* with a site worker who uses technologies in his daily tasks
Case 3	7	*1* with an OSH professional *3* with OSH managers *2* with VDC professionals *1* with a VDC manager

Table 2 Background information

Case	Position/ pseudonym	Age	Time working for case	Background/education
Case 1	OSH professional 1	63	Five years	OSH coordinator course
	OSH professional 2	37	Eight years	Plumber background Mandatory OSH course
	OSH professional 3	52	Less than a year	More than 20 years of experience from the construction industry
	OSH professional 4	?	Over 30 years	OSH representative course OSH coordinator course
	OSH manager	57	Less than a year	13 years of experience as OSH manager for a similar company Chemical engineer background Master's in OSH management
	VDC professional 1	37	Five years	Construction management and informatics background
	VDC professional 2	28	Six years	Civil engineer background
	VDC manager	35	10 years	Construction engineer background
Case 2	OSH professional 1	59	Less than a year	More than 25 years of experience with OSH Environmental technician background
	OSH professional 2	60	Over 10 years	Worked with OSH in other companies Construction worker background
	OSH professional 3	?	30 years	Construction management background
	OSH professional 4	48	Two years	Blacksmith background
	OSH professional 5	31	Less than a year	Six years of OSH experience from other companies Landscape gardener and business and landscape management background
	VDC professional 1	44	10 years	Construction management background
	VDC professional 2	26	Two years	Construction management background
	Site worker	67	?	Concrete worker and crane operator

(*Continued*)

Table 2 (*Continued*)

Case	Position/ pseudonym	Age	Time working for case	Background/education
Case 3	OSH professional	?	Three years	Worked with OSH for several years in other companies
	OSH manager 1	?	?	?
	OSH manager 2	54	8 years	25 years of experience from the construction industry Construction management background
	OSH manager 3	53	Less than a year (as OSH manager)	33 years of experience from the construction industry Technical assistant background
	VDC professional 1	40	Five years	Construction worker and construction management background
	VDC professional 2	37	?	22 years of experience from the construction industry Construction worker and construction management background
	VDC manager	28	Three years	Construction management background

The data collection took place from 2019 to 2022. The interviews each lasted circa 1 hour and were conducted by the same two researchers, who took turns either conducting the interview or mainly listening, taking notes and ensuring all questions were asked. In case 1, all interviews were conducted online. In case 2, only one interview was conducted online, and in case 3, all interviews were conducted in person. The interviewees all consented to participate in the study and to be recorded. In the beginning of each interview, the interviewees were informed of the purpose of the study, including that results were only for research purposes. All cases and interviewees were pseudonymized.

All interviews were transcribed and processed in NVivo12.

3. Professional identity

3.1 Professional identities of OSH and VDC professionals

As Giddens (1991) has pointed to, reflexivity of one's self is a key aspect of modern society. The creation of an identity becomes increasingly important for human beings in an ever-changing world, where we feel the need to hold on to a certain identity in order to experience a sense of certainty and meaning. There is general agreement that we as human beings feel committed to certain identities (Davies & Harré 1990; Goffman 1967).

The question of identity has also been examined in an organizational context, where professionals increasingly navigate complexity and uncertainty (Buch & Andersen 2013). For instance, Wieck's (1997) theory of sensemaking has been used to illustrate how our definition or sensemaking of the world contributes to the construction of identity – for example, the process of how employees construct their job and therefore identity (Kamp 2011). Several other studies have examined professional identities, as they may have both a legitimizing effect (Ajslev et al. 2022; Alvesson & Willmott, 2002; Buch & Andersen 2013) and an impact on one's well-being (Davies & Harré 1990; Goffman 1967).

Specifically, attention has been paid to the identities of OSH professionals. These studies point to a number of identities that OSH professionals ascribe to, but those of being an expert, displaying interpersonal skills, challenging current practices, and having motivation for the cause of safety seem to reappear (Ajslev & Møller 2023; Ajslev et al. 2022; Hale 1995; Provan et al. 2018, 2017). While these aspects of OSH professionals' identity are relatively fixed, previous research has pointed to the fact that changes in work may challenge professional identity (Buch & Andersen 2013). Le Coze (2024) has noted that OSH professionals struggle to integrate new practices into their work, which may lead to job dissatisfaction. Therefore, it is interesting to examine how new practices (such as using technologies for OSH purposes) may affect the professional identities of OSH professionals.

While VDC professionals have been given less attention in the literature, it has been pointed to that they are expected to exude technical knowledge. The educational background of a VDC professional is of lesser importance. Rather, training in computer science or IT and understanding of the construction process are important. Skills of communication, pedagogy, collaboration, dedication, a proactive nature, and structure have been highlighted as central (Gustafsson et al. 2015). Additionally, it has been pointed to that it would be fruitful for VDC professionals to develop skills in direction of OSH (Ajslev & Nimb 2022).

3.2 Analytical approach

In the analysis, a positioning-analytical perspective (Davies & Harré 1990) was applied to investigate the professional identities of OSH professionals and VDC professionals. According to this theory, subjects are positioned through speech acts through which they are ascribed characteristics – by others and by themselves. There can both be interactive positioning where one person's speech action positions another and reflexive positioning where a person ascribes characteristics to themselves. The theory distinguishes between the concept of a person and the concept of a subject, the latter of which is made up of positions made available through discourses. Through this analytical framework, we gain insight into the positions that interviewed OSH professionals and VDC professionals either adopt or reject as well as discourses that are available for the positioning and therefore their identities. The available positions may draw on a shared story or a desired identity (Ajslev et al. 2017, 2019; Davies & Harré 1990). This perspective is particularly relevant to examine because of the overlap or lack of overlap between the professional identities of OSH and VDC professionals and can help explain how use of technologies for workplace purposes is progressing within the three cases. At the same

time, this perspective can shed light on areas with potential for increased mutual understanding between the two examined professional groups, and highlight areas where each group can strengthen their focus on workplace safety by identifying more closely with either VDC or workplace safety itself. With the application of positioning theory, it is possible to analyze how the interviewees position phenomena, such as technology, and how these relate to and affect their professional identities.

Recent research has examined the professional identities of OSH professionals in various contexts. For instance, it has been highlighted that OSH professionals in the construction industry perceive themselves as guardians or puzzle-piece caretakers, necessary evils, peripheral decision-makers, risk assessors, alliance builders, and/or orchestral leaders (Ajslev et al. 2022). The puzzle-piece caretakers or guardians are characterized by their motivation for OSH and perceive themselves as a small piece in a complex organization – a position that can complicate their work but at the same time partaking in the larger puzzle can be a source of passion for OSH professionals. The necessary evil feels at odds with other stakeholders and feels that others do not sufficiently care about their efforts in the OSH field. The peripheral decision-makers position themselves as excluded from big decisions, for example, budgetary decisions, and as someone whose job can be done relatively fast. To promote OSH, the OSH professionals sometimes position themselves as risk assessors who are capable of coming up with solutions quickly and who have a lot of knowledge of the construction industry. Unlike the necessary evil, the identity of alliance builder is characterized by being engaged with all stakeholders. The alliance builders are positioned as collaborative and good at building relations. Lastly, the orchestral leader is characterized by their ability to balance between being pleasing and policing (Ajslev et al. 2022). The analysis takes a starting point in these professional identities to gain an overall understanding of how OSH and VDC professionals position themselves. The same OSH professional may position themselves in relation to several identities in different situations. However, the analysis expands upon these professional identities by examining how the introduction of technologies and potential interdisciplinarity affect the professional identities of OSH and VDC professionals. Interdisciplinarity is defined as *the fact of involving two or more different subjects or areas of knowledge* (Cambridge Dictionary 2025). The analysis will examine the interdisciplinarity between OSH and VDC as two areas of knowledge.

For the first part of the analysis, focus was on the professional identities of OSH and VDC professionals. First, themes of identity were found across all interviews. The identities that were found across several interviews were included in the analysis. As such, included quotations are exemplary. This part of the analysis was relatively open, allowing for insight into positions that the interviewees identify with. Next, the before-mentioned six identities (Ajslev et al. 2022) were applied to the themes. This helped organize the results and related them to already existing research. Thereby, an abductive approach was applied that allowed for an open analysis that could replicate the actual identities of the OSH and VDC professionals while still drawing upon theory of identities.

After completing the first part of analysis, the researchers went through the material again with the purpose of finding out more about how interdisciplinarity would affect the professional identities that were found in the first part of the analysis. This open-ended approach allowed for the researchers to not base the analysis on other studies but rather to understand the interdisciplinarity through the lens of the interviewees who are the ones affected by the collaboration between the OSH

and VDC professions. Focus in the second part of the analysis was to find out how interdisciplinarity between these two fields would affect the professional identities of OSH and VDC professionals through a positioning-analytical perspective (Davies & Harré 1990). In this part of the analysis, an abductive approach was applied. Again, the quotations included in this part of the analysis are exemplary for themes across several interviews.

While this study builds upon already existing research on OSH professionals' professional identities, it adds to this area of research by addressing the introduction of technology into the work of OSH professionals. As the use of technology continues to expand and impact the work of many professions, it is of utmost relevance to examine how it affects the professional identities of OSH professionals, as this area of knowledge is currently lacking.

4. Results

4.1 How do the OSH professionals and VDC professionals identify professionally?

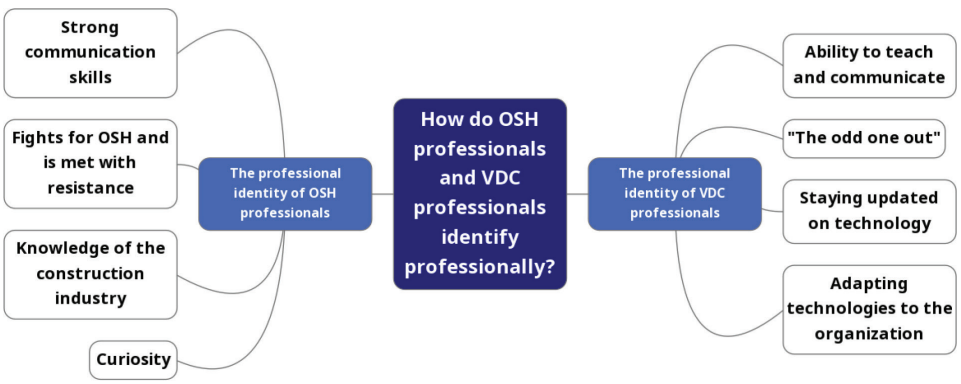

Figure 1. Professional identities of OSH and VDC professionals.

4.1.1 The professional identities of OSH professionals

The OSH professionals are responsible for OSH on the construction sites. Their work includes a variety of elements, such as doing safety rounds, making risk assessments, and making sure work complies with OSH legislation. Across all three cases, OSH professionals position themselves as individuals with strong communication skills and knowledge of the construction industry. This is exemplified in the following quote:

> To a large extent it's about getting people to talk with each other – simply walk up to them and say, why are there barriers here? That may be the underlying education or dialogue task that is central, and connected to the other job – which I think we make a virtue out

> of in this company – which is to be visible and get around the construction site. Talk to those people that want to talk to me. Or just take initiative myself to start a conversation. And the method is simply to be curious about what people do. You learn a lot from that and it is a way to function as a coordinator. You receive information about many things that are not necessarily visible by just observing the construction site or by talking to the construction manager or in a different way finding information. So, I think gathering information and communication and the fact that it is synergistic can work together. That is an important job for me.
>
> (OSH professional 1, case 2)

In different ways, all OSH professionals position conversation, being curious and asking questions as central and thus consider communication to be one of the most important tasks. In this sense, the interviewee reconfigures his identity in a way similar to the description of an alliance builder and puzzle-piece caretaker, who is solution-oriented, cooperative, and capable of building relationships with all parties involved in construction work (Ajslev et al. 2022). The quote exemplifies how several interviewees inscribe themselves into particular identities known from other studies of OSH professionals.

While this may be the case, the results are nuanced as several of the interviewed OSH professionals also mention challenges associated with this cooperation. Many find it difficult to gain traction and to obtain an impact when it comes to OSH. This can be due to economic barriers from the company's side or due to barriers related to construction workers, for whom OSH initiatives are at times perceived as a time-consuming obstacle. This speaks to a general prioritization of efficiency over safety in the construction industry which is related to a higher number of accidents (Johansson et al. 2010; Lacey et al. 2007; Lingard 2019). The following quote is an example of an OSH professional who feels his efforts to promote OSH are not always appreciated:

> Everyone is dissatisfied. All the time. It is rare to have someone tell me I have done a good job. I think for the first six months, I did not hear it once. Then there were two colleagues, one from the company and a surveyor, who said that I managed it well. And that means something to me, to have a colleague say that. But every day then there is mud, then there is a wrong barrier. Everyone wants it in a different way. (…) the barrier down there had not been accepted, if I had put it up. Not because my work would have been worse, but just because if it had been me, who had to put it up, they would simply not have accepted it.
>
> (OSH professional 4, case 2)

The OSH professional exemplifies how OSH professionals meet resistance from the workplace. In this way, he positions himself as someone who must fight for OSH, where his work is met with a lack of acceptance. Thus, he reconfigures the professional identity of an OSH professional as a necessary evil (Ajslev et al. 2022) that is responsible for OSH but in conflict with relevant parties. This exemplifies the positioning of the OSH professional as someone who must fight for OSH and faces considerable resistance in doing so.

4.1.2 The professional identities of VDC professionals

The VDC professionals are in charge of the use of technology on the construction sites, including the digital strategy, guidelines and how technology can specifically be used to support construction projects. They are responsible for this in all phases of the construction project, and they assist coworkers on how to use technologies such as Dalux. Across all three cases, VDC professionals position themselves as teachers and assistants to others in adopting and using technologies in the best possible way. This is exemplified in the following quote:

> I teach them for a couple of hours and then they have to do the work while I oversee and coach them. We [the VDC professionals] do it [the teaching] in different ways but I care a lot about for example that they take control of the mouse themselves.
>
> (VDC professional 1, case 2)

Although there is variation in exactly how this is done, all the VDC professionals express it is essential to be able to teach and develop ideas on how to make technologies work within the organization, while also staying updated on new technologies. In this way, the VDC professionals reconfigure their professional identity around possessing a range of technical competencies and applying these within the organization. This professional identity shares traits with the identity of the puzzle-piece caretaker and the risk assessor (Ajslev et al. 2022), by focusing on adapting technologies to organizations. Following this line of thinking, the VDC professionals position themselves as supporters who are there to assist and educate people. Another key element is using their support role and strong communication skills to teach people how to use the technologies. In doing so, they position themselves as alliance builders (Ajslev et al. 2022) and experts in their field.

Collaboration with relevant stakeholders can present challenges in the work of a VDC professional. In case 3 specifically, there is a difference in how the VDC professionals position this. Some experience their ideas being well-received. In contrast, others from the same case position themselves as the odd ones out:

> You are in a position where you are checking someone else's work. So you do it with the best intentions because you want the best project but sometimes it feels like you are the odd one out in this game. (…) there is a reason why you are the odd one out. Still, you have to be the one who everyone shoots at because the project management (…) has their responsibility with the architect or the engineer or advisor. They would rather not come across as not having done their job well. Because what was turned in is through them – collaboration with their advisor that they manage in this enterprise. So you step on peoples' toes by highlighting that something has gone wrong.
>
> (VDC professional 1, case 3)

The VDC professional positions himself as the odd one out, where he inevitably steps on the toes of collaborators because his task is to inform them when they have made a mistake. In this context, the VDC professional positions himself as someone who performs work that is crucial for the organization, but also work that is rarely well-received

by partners and advisors. This reconfigures his professional identity as a necessary evil (Ajslev et al. 2022), responsible for bringing attention to issues to improve the construction project, thereby challenging current practices (Provan et al. 2017).

4.2 Interdisciplinarity between OSH and VDC

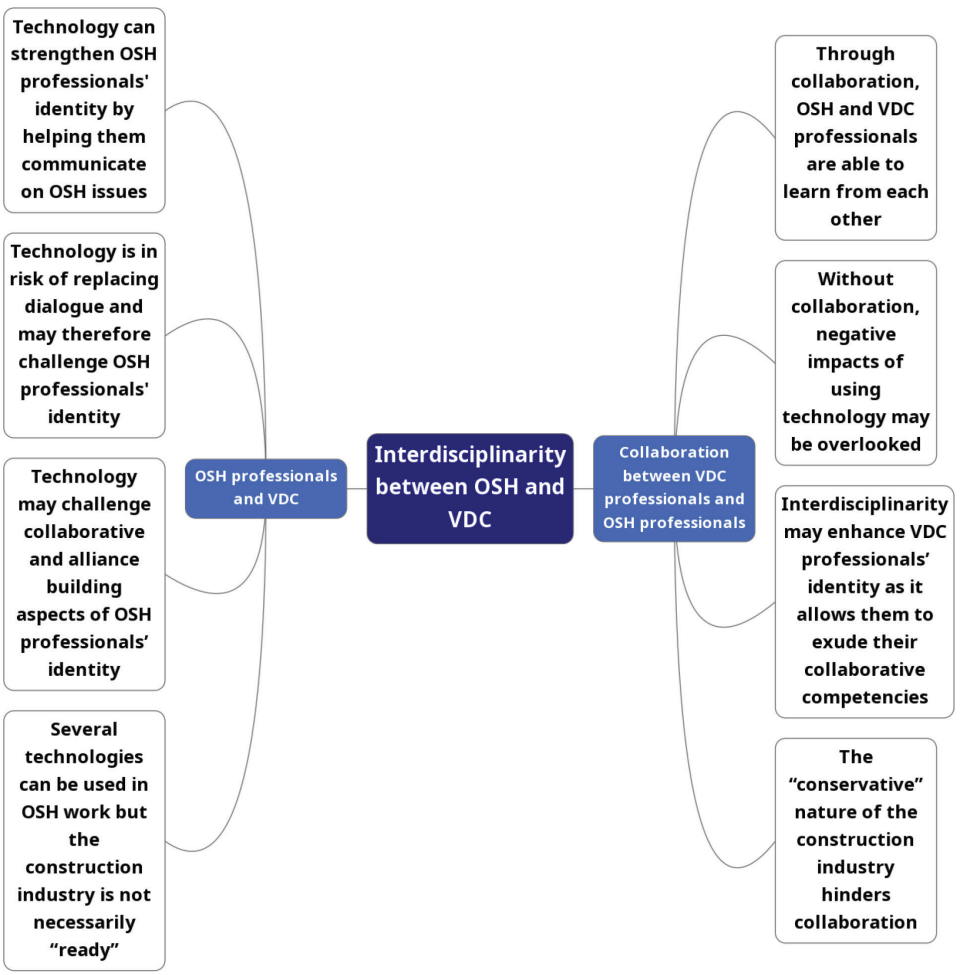

Figure 2. Interdisciplinarity between OSH and VDC.

4.2.1 OSH professionals and VDC

None of the OSH professionals mention VDC when asked about the main qualities one needs to fulfill the job. This shows that VDC is not a central aspect of their professional

identities. On the other hand, several OSH professionals mention several ways in which VDC is used in their work and position technology as a phenomenon with potential in relation to OSH work:

> I know that you can always improve for example through VDC. I think we have come pretty far, but I do not think we ever…you can never have a site without any risks because we are working with people. (…) I do not think you'll ever get rid of people like me, who walk around and keep talking about OSH. I do not think so. (…) But I think that my job can be made easier by being able to see a lot of things earlier on, some VDC can catch things earlier with the people from production. So perhaps I have not been there as much as I am right now, but I do not think you will ever get rid of it. I cannot imagine.
>
> (OSH professional 3, case 1)

The OSH professional exemplifies how VDC as a phenomenon may enhance work because it has made it easier to spot problems early on. However, the OSH professional ultimately positions the OSH professional as indispensable in making sure that communication about OSH takes place. Therefore, technologies are capable of supporting the work of an OSH professional but will not completely change or replace it.

Several OSH professionals position technologies as phenomena, which may support their work:

> (...) We actually use Dalux on all our projects. And it's an easy way to communicate, to see a flow through the process, and to send things from one person to another, which is really smart, right? (...) So when you're out on-site, you can just type it in, and it goes straight to the person who can then act on it faster. You could say it's a great tool because it allows people to react quickly without having to call first and risk forgetting something. You can simply be out there with your iPad and enter it right away.
>
> (OSH professional 3, case 2)

> Plus, in connection with having Dalux on the project, we chose – or rather, I chose very early on – to move away from the old method of using a Word document and an Excel sheet. It just doesn't make sense because when you have such a large site, it's crucial that communication with those responsible is as fast and solution-oriented as possible. (...) This way, we get communication that is very fast, meaning that within one to two days, we have actually resolved the issue. What that does is ensure that nothing remains unresolved – either we implement a solution, or we figure out whether we should go one way or another.
>
> (OSH manager 3, case 3)

Dalux can support the work of advancing OSH, as it provides opportunity to react quickly to problems. In this way, technologies have potential to strengthen the aspect of their professional identity, which is to make an effort for OSH and fight for it. By using this type of technology, the OSH professionals can enhance their communication, which Dalux helps improve by making it easier and faster. In this way, the use of technology supports a very central part of the OSH professionals' professional identity, which has to do with being a strong communicator.

There are, however, exceptions to this positioning. Across several interviews with the OSH professionals, they position technology as a phenomenon that is at risk of replacing dialogue:

> Well, I think that all this e-learning, video, and training have done a lot of things – it has made some things better and easier. It saves a lot of resources once it's created because then you can just send it out to people. But on the other hand, you don't get the dialogue, and you also don't get the same... I mean, classroom training has some advantages that e-learning doesn't. (…) With classroom training, you get a sense of the people in the room. You can see if they are paying attention or dozing off, you can ask them questions, and you can engage them in a completely different way. You can ask them to discuss certain topics – something you can't really do with e-learning. With e-learning, it becomes more about checking whether they have paid attention when they have to answer questions afterward, right?
>
> (OSH manager, case 1)

As mentioned in the quote, the use of technology comes with several advantages and may even enhance their professional identity of being good communicators, as it supports the work of teaching others. Contrary to that, the use of technology may also challenge their professional identity – which to a large degree has to do with building relationships and communicating – as it might replace the physical meeting. Several OSH professionals position technologies as such, which further underlines the importance of this part of their professional identity. Therefore, there is a clear difference in the way in which technology is positioned by the OSH professionals. On one hand, technology is advantageous in many ways, but on the other hand, it may challenge a very central aspect (communication) of their identity and make it more difficult for them to assess whether or not people actually learn from their initiatives.

Several of the OSH professionals position new technologies as something that may complicate the work of doing rounds, observations, and coordination of initiatives. This is because technologies bring the opportunity to document everything, which then ends up being the responsibility of the OSH professional. This perspective is exemplified below:

> But I have started using Dalux because there has been a desire for it on some of our construction sites. I have been a bit hesitant about it because, I mean, it's smart in some ways, but in other ways, I honestly don't really see the difference between one system and another. Plus, the way I see it, it disconnects the construction management. For example, if you're assigning a task to the carpenter, he gets the task saying, you need to do this and that, but the responsible contract manager is kind of left out. He can see the overview, but he hasn't received the task directly. And sometimes, things need to be pushed through, including by our construction management, right? (...) When only the carpenter gets the task, then it's up to him to do something. There's no one automatically checking whether the carpenter has something pending. At least, we don't often experience people proactively going in to check if their subcontractors have something they need to follow up on. They need that push, that notification, saying, Okay, you have a task here that you need to take care of.
>
> (OSH professional 2, case 2)

In the quote, the OSH professional explains being hesitant toward the use of Dalux because it may disconnect project management. The OSH professional positions this technology as a phenomenon that might reduce collaboration and increase the need to follow up – which might end up being the responsibility of the OSH professional. Therefore, technology is further in risk of challenging the professional identity of OSH professionals, as it may reduce collaboration and alliance building – key aspects of their identity. However, as mentioned in the quote, OSH professional 2 also sees some advantages of using technology. Sometimes, the lacking parts of using technology in OSH work have to do with the design of the technology, such as someone being able to see an overview but not receiving a task directly. This means that while technology may be useful in OSH work, it is not necessarily designed with this in mind and thus does not always work optimally in this context.

There are, however, several ways in which different technologies can be used in OSH work. Across the interviews, the OSH professionals give several examples of how technology is used in their work, while also mentioning ways in which they could use technology but do not yet:

> I: (…) Which technologies do you work with? (…)
>
> R: (…) What I'm using it for at the moment isn't really much more than trying to ensure we get the right data in so, in the long run, we can extract the right data again. In relation to being able to do some statistics. We don't really have any proper programs or platforms (…), for OSH registrations, so unfortunately, it is done in a very old-fashioned and outdated way with Excel and SharePoint and things like that. So, there isn't much technology involved. Then we have our BI reports (…) That's where we extract data and present it in a way so managers can see how things are going with their accident frequency, deviations, absenteeism, and all sorts of things – so they get easy access to the data that we actually want them to keep an eye on. And it's really about setting it up in a way that makes sense to them so they can easily access and follow it. We can't expect them to keep track of how many accidents they have if they can't see it anywhere. (…)
>
> I: How do you use e-learning, you say?
>
> R: Well, we have an e-learning program through our HR department, where we can ask them to help upload content, and then it gets sent out to employees. It can be just text, it can be videos, it can be comics, it can be quizzes – it can be all sorts of different things. (…) We have also just invested in Defgo, which is a survey program for running well-being surveys, workplace risk assessments, and things like that.
>
> (OSH manager, case 1)

Technologies are used to register accidents, teach employees about OSH, and carry out employee satisfaction surveys and workplace risk assessments. These are key tasks for an OSH professional, whose main purpose is to contribute to the improvement of OSH. Several of the OSH professionals mention ways in which they can use technologies for OSH purposes, and in this way, technologies can support their work and professional identity. However, the OSH manager say that they still do things in an 'outdated' and

'old-fashioned' way. This speaks to the fact that while individual OSH professionals may see the potential of using technology in their work, the industry still sticks to its usual practices. A limitation to using technology for OSH purposes is therefore that the industry is not 'ready' to take on VDC.

4.2.2 Collaboration between VDC professionals and OSH professionals

Across the interviews with OSH and VDC professionals, several interviewees talk positively about collaborating with each other across professional boundaries:

> (…) because the VDC people are out on the projects, the fact that they have moved out to be on-site is definitely a big gain for everyone. Because then, we can also start to see that, as OSH professionals, we are not necessarily aware of what VDC can actually do, what possibilities it offers. And that's exactly why, when collaboration begins on projects out there, good ideas start to emerge, right? And that's also why we have created a focus group where OSH and VDC work together – because we can clearly see that there are some intersections that add real value, right?
>
> (OSH manager 2, case 3)

Across the interviews, not everyone collaborates as exemplified above, however, the ones that do generally position this collaboration as a positive phenomenon, where they are able to take advantage of each other's expertise and learn from each other. Through collaboration, they are able to approach problems with a new perspective. Therefore, collaboration across professional groups is positioned as a phenomenon that will create more knowledge and add value to the work of the two groups. This also has to do with the fact that some aspects may be overlooked without collaboration:

> They [the VDC professionals] just sometimes forget some OSH aspects, right? And I think the same can happen if you're working in VDC and production planning – you might overlook certain aspects of the planning that could have a negative impact on OSH, even though they might sound completely reasonable in other contexts. So, it's good to have a kind of… a joint effort or a shared review (…).
>
> (OSH manager, case 1)

The OSH manager positions VDC professionals as someone, who might overlook OSH aspects. A so-called 'joint effort' is positioned as a way to overcome this. Therefore, the collaboration between OSH professionals and VDC professionals is positioned as a way to enhance the use of technologies for OSH purposes and as a way to not overlook the risks that technology may have for OSH. This is a key point considering that several studies have pointed to the potential negative impacts of technology on OSH (Ajslev & Nimb 2022; Ajslev et al. 2024; Humlum et al. 2024; Nisafani et al. 2020). By collaborating with each other, the two groups will gain a better understanding of these potential risks.

For the VDC professionals, teaching and assisting others in technology is a central part of their professional identity. This competence can be present in their collaboration with the OSH professionals, as one interviewee states:

> I myself am involved in OSH where we have – I think it's three people – we have connected to our OSH organization, who actually don't work with VDC or know anything about 3D modeling or geometry. And they have found what we have introduced to be very useful (…) so it makes OSH a bit more exciting to engage with. It's not just someone standing and talking, as it usually is, and then you get a sticker, and suddenly you know everything about a particular construction site. Instead, it's more about building a culture around it, so it becomes ingrained. And it's also a bit more fun to navigate a 3D environment where you're presented with questions (…) it just adds more value to present it in this way, and I've found that to be very rewarding.
>
> (VDC professional 1, case 3)

For the interviewee, being invited into the work of the OSH organization is very rewarding. The OSH organization has found the inputs of the VDC professionals to be very useful, and in turn, the VDC professional finds that their work adds value to the OSH by making it more exciting and engaging rather than using traditional methods. The VDC professional talks about building a culture around OSH and ingraining technologies into this. As such, the interdisciplinarity is positioned as adding great value to the OSH, as technology will enhance the OSH work. With the collaboration with OSH professionals, the VDC professionals have the chance to teach how to use technology. The VDC professionals position this phenomenon as rewarding. Therefore, collaboration is perceived as positive because it gives the VDC professionals the chance to exude their teaching competencies.

There are, however, barriers to this collaboration. Across several interviews, the construction industry is positioned as conservative, by both VDC and OSH professionals:

> It's funny, isn't it? It's probably the place with the worst OSH, but it's also the most conservative industry, the one that's furthest behind in using the tools that become available. Things are still done the same way they were in the old days. So there's a huge potential, a massive gap that we need to try to work on.
>
> (VDC manager, case 3)

> I'm absolutely sure when it comes to new technology, we have some major breakthroughs that need to happen in the industry because we're a bit too conservative and too loyal to the way we normally do things or have always done them. So here on the construction site, the goal should be to challenge ourselves – with VDC and different systems, one way or another.
>
> (OSH manager 3, case 3)

Consequently, the 'conservative' industry struggles to capitalize on technological opportunities for OSH within the sector. Technology is often viewed as opposing the construction industry, which is positioned as outdated and resistant to change, despite technology's potential to enhance the already challenged OSH. As a result, the construction industry is positioned as conservative regarding both technology and OSH, which may hinder efforts to broaden knowledge in these areas, particularly in

a collaborative context. This situation also risks amplifying the identities of VDC and OSH professionals as outsiders and being met with resistance, respectively. Therefore, although collaboration between the two has potential for positive advancements, the surrounding structures may create obstacles to this collaboration and further complicate their efforts.

5. Concluding discussion

The purpose of this study was to examine the professional identities of OSH and VDC professionals and how an interdisciplinary approach between OSH and VDC would affect these identities. In the following section, we discuss the results' implications for the use of technology for OSH purposes as well as future paths that may be fruitful for enhancing interdisciplinarity.

The construction industry continuously incorporates digital tools solely to improve workflows rather than also using the tools for safety (Afzal et al. 2021). This potential has yet to be fully taken advantage of although VDC has several positive implications for OSH in the construction industry (Babalola et al. 2023).

VDC has been identified as a superior alternative to traditional methods for enhancing safety within the construction industry (Afzal et al. 2021). Numerous studies prove the ways in which VDC can improve OSH (Ajslev & Nimb 2022; Babalola et al. 2023; Nykänen et al. 2020; Shafiq & Afzal 2020). Throughout interviews in this study, technology was positioned as a powerful tool to carry out safety training, which is backed up by other research (Ajslev & Nimb 2022; Babalola et al. 2023). Thus, VDC is well suited to educate on OSH. This is a concrete example of an area where interdisciplinarity makes sense. The interdisciplinarity between the two professional groups has potential to enhance VDC professionals' identity of being experts in their field, as it allows them to use their skills to expand the general knowledge of OSH in relation to VDC. This is especially relevant considering the fact that VDC professionals wish to adapt the technologies to the needs of their organizations. Additionally, it is interesting to note that VDC professionals in case 3 were all oriented toward OSH in the construction industry. The reason for this particular orientation in case 3 may have to do with these VDC professionals having a background as construction workers (see table 2) and therefore have experienced the execution of safety initiatives themselves. This former experience could enhance the interdisciplinarity between the two fields, as the VDC professionals then have a certain interest in the field of OSH.

OSH professionals in case 1 in particular do not position technology as a central part of their work. While several of them see advantages of using VDC, they are highly aware of their own professionalism. It is of high relevance to address and maintain a focus on how the technologies affect OSH professionals' ability to act as alliance builders, influencers, and communicators – bridging relationships between production demands and OSH measures (Ajslev & Møller 2023; Provan et al. 2017). Here, this study emphasizes the need for paying particular attention to the needs for maintaining practical and in person-relationships that enable OSH professionals to take on these identities and upholding good working relationships with workers and managers alike. This while also increasing their technological understanding and skills in order to make use of the potentials for collecting data as well as improving communication and

planning through VDC technologies. It is important to note that while some interviewees in case 1 showed skepticism, they (and the interviewees from other cases) also noted that the use of VDC can in fact be advantageous. This difference between cases (more skepticism in one versus more positivity in others) points to the importance of developing technical competencies while still maintaining the professional identity of being a good communicator.

One barrier for using technology for OSH work is resistance from the construction industry, as noted by several OSH and VDC professionals. In construction companies, it can be challenging to make a significant impact, and implementation may be hindered by a lack of resources. For example, new initiatives might be perceived as time-consuming or costly. Additionally, companies may resist because they do not see the benefits of integrating technologies into their work. Consequently, interviewees point to company resistance to both OSH initiatives and technologies, which is often related to companies not recognizing advantages or believing implementation is too resource-intensive. This is also reflected in statements that describe how VDC professionals are oftentimes not aware of OSH impacts of the application of technologies, which lines up with earlier research pointing to a similar matter (Alomari et al. 2017; Bong et al. 2015; Che Ibrahim & Belayutham 2020). While this is not always the case, as we also see situations where VDC professionals are actually oriented toward OSH, it seems that further collaboration and interaction between the two fields could be highly fruitful for unleashing OSH potentials connected to the new technologies. A particular potential for improving this collaboration could depart from an increased recognition and alliance building centered on commonalities between the two groups of professionals' identities.

Both VDC professionals and OSH professionals position themselves as puzzle-piece caretakers and emphasize the importance of understanding the company's context and daily operations when introducing new initiatives. Positioning their professional identity as part of a larger organizational puzzle could be useful in addressing resistance. This is backed up by previous research which points to a number of organizational factors as important for implementation – these include the organization's resources (time and money), the 'readiness' for change in the organization, and the compatibility of the implementation process with the organization (Wåhlin-Jacobsen et al. 2022). The resistance indicates a need for OSH and VDC professionals who can empathize with other actors within their companies and effectively communicate how new initiatives can be beneficial. Thus, OSH and VDC professionals must be equipped to confront resistance and overcome it, particularly through communication and alliance building practices.

As VDC professionals wish to be part of the workplaces' larger 'puzzle', it could be argued that a piece of this is the reality of the construction industry being met with severe OSH problems such as a high risk of accidents, musculoskeletal disorders (Lingard 2013) and psychosocial hazards such as stress and fatigue (Lingard 2019). VDC has potential to improve these problems (Afzal et al. 2021; Ajslev & Nimb 2022; Babalola et al. 2023; Nykänen et al. 2020; Shafiq & Afzal 2020). As such, in order to contribute to the construction industry's larger 'puzzle', VDC professionals could advantageously take into consideration how their expertise and knowledge in regards to VDC can also increasingly become a contributory driver in improvement of the severe OSH issues faced by the industry. In this way, their professional identity could potentially be enhanced through the incorporation of OSH.

A way to enhance or support the expert identity of VDC professionals is the ability to keep up with the potentials of VDC – such as using VDC for OSH purposes. By promoting this agenda and guiding enterprises in how to use VDC for this purpose, VDC professionals can come across as experts with extensive knowledge of VDC and their potential uses that could be perceived as crossing a boundary of the original purpose of VDC which solely included business objectives (Del Savio et al. 2022).

Several interviewees also highlight a conservative culture within the industry, which can further challenge implementation of new initiatives. While initial resistance might evolve into positive adoption of new initiatives or technologies, the conservative culture remains a persistent factor in construction, where unfavorable OSH conditions are often seen as an unavoidable part of the job (Ajslev et al. 2013; Boatman et al. 2015). As a result, OSH and VDC professionals find it difficult to implement new measures. Both groups see themselves as performing essential work, though they recognize their efforts may not be well-received by companies. These perceptions point to a barrier to implementing VDC for OSH purposes.

Overall, resistance from companies – whether temporary or rooted in a more pervasive conservative culture – represents a barrier to using VDC for OSH purposes. Companies must recognize the benefits of these technologies, which can simplify their work while also serving OSH objectives.

This study has shown that use of technologies for OSH purposes may both challenge and support the identity of OSH professionals. The expansion of technology in industry calls for OSH professionals to develop competencies in this area while maintaining their ability to communicate and uphold human relationships across the plethora of organizational actors in construction. The collaboration between OSH and VDC professionals supports identities of both OSH and VDC professionals, however, the conservative culture of the construction industry poses a barrier to this collaboration. The study has contributed to understanding of the way in which technological advancements affect occupational identities – an interdisciplinary approach between the fields of OSH and VDC both supports and challenges professional identities. Future research should focus on ways in which OSH professionals can develop technological skills while still maintaining their communicative abilities and how to overcome the barriers posed by the industry. The results are relevant for the construction industry, both the companies and social partners of the sector, who wish to enhance OSH through the use of technology.

In Denmark, large construction companies (similar to the case companies) typically have both OSH and VDC departments dedicated to each area of work. As such, the focus on interdisciplinarity between OSH and VDC is particularly relevant in a Danish context. While that may be the case, international studies point to the need for some form of interdisciplinarity between the two fields (Felknor et al. 2020; Holden & Vassie 2010). The OSH profession is prevalent in several international studies (EU-OSHA 2024; Felknor et al. 2020; Hale 1995; Holden & Vassie 2010; Le Coze 2024; Provan et al. 2017, 2018; Provan & Pryor 2019). Thus, the focus on the effects of VDC on the identities of OSH professionals is relevant not only in a Danish context, but in an international one as well. While the focus on VDC professionals specifically is mostly prevalent in Nordic studies (Ajslev & Nimb 2022; Gustafsson et al. 2015), several international studies focus on similar professionals in the construction industry (Alomari et al. 2017; Bong et al. 2015; Che Ibrahim & Belayutham

2020). This speaks to the fact that a focus on effects of interdisciplinarity on the VDC professionals' identity is not only relevant in a Nordic context and should be more broadly researched.

5.1 Strengths and limitations

This study builds upon already existing knowledge on professional identities but adds to the field by highlighting the ways in which the use of technologies affects professional identities. As technological tools continue to develop and be implemented in organizations, it is of high relevance to focus on this area of research presently. In this regard, it is however important to take note of the pace at which technology is implemented and changes work. It may be urgent for research to keep a continuous eye on such developments since the pace is ravaging. As such, interviews gathered in 2019--2022 may also be behind current developments in practice.

In this study, we included both employee and manager perspectives on the use of technologies and interdisciplinarity. As other studies point to differences in these two perspectives, it is relevant to consider the implications for this study. While there were no notable differences in the two perspectives (which may have to do with the subject matter being fairly uncontroversial), it could have been interesting to investigate the conservative nature of the construction industry further and to point to ways in which this could change and thereby support the interdisciplinarity between the two professional groups. Several studies point to the construction industry being challenged in collaborating and communicating across different organizational levels and professional groups (Bresnen & Marshall 2000; Dubois & Gadde 2002; Flyvbjerg & Gardner 2023; Jeschke et al. 2021; Kines et al. 2010). Further research is needed to point to ways in which this issue may improve and how this could potentially lead to interdisciplinarity between OSH and VDC that is not hindered by the conservative nature of the construction industry.

Through the lens of professional identities, this study has pointed to ways in which use of technology may be enhanced through interdisciplinarity and support OSH work. Future research should further explore this perspective and investigate how technology may support interdisciplinarity and enhance professional identities as well as possible barriers to this.

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