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Configuring Augmented Reality Users: Analyzing YouTube Commercials to Understand Industry Expectations

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ABSTRACT (150 words)

Commercial videos are often used to familiarize potential buyers and users with new technologies and their possibilities. In addition, presenting visions of future applications is a way to configure users and define social worlds of technology use. We analyze 30 YouTube videos featuring augmented reality (AR) devices in industrial manufacturing and construction, to explore how these commercial videos situate AR technology and future users by showcasing techno-euphoric promises and imagined use cases. With a video analysis based on Grounded Theory and Situational Analysis, we untangle the promises of AR for manufacturing and construction work; second, we present two prevailing configurations of AR users: “experts in situ” and “smart dummies**;**” and third, we discuss how YouTube videos put forward developmental expectations. In addition, we identify discrepancies between expectations and foreseeable requirements in construction work. Finally, our research could contribute to a more holistic understanding of workplaces and socially robust AR applications.

Additional Keywords: Augmented reality, user configurations, video analysis, manufacturing, construction
Word count: 11.663

1 INTRODUCTION

The digital transformation in the construction industry is promising but also comes with **specific** challenges. Studies about augmented reality (AR) applied to real use cases in construction are still work-in-progress. In this paper, we present promises of AR technology use and assumptions about future users based on an analysis of commercial YouTube videos.

The global construction sector has been criticized for its low productivity and efficiency and is confronted with an increasing shortage of skilled workers [1]. Moreover, the construction industry differs from other industries such as logistics or manufacturing of serial mass products. The value chain within the Architecture, Engineering, and Construction (AEC) sector is still dominated by the creation of individual buildings and high safety standards on prefabrication and construction sites. Stakeholders expect that incorporating digital technology in this sector is a key step in the modernization of the construction industry, besides enhancing job attractivity [2]. Implementing wearable technologies, such as AR glasses or handheld devices, promises to improve productivity and job attractivity with visual assistance for workers during construction tasks that still require human labor [1].

AR technology, which “combines three-dimensional, real-time, and interactive virtual graphics with physical space” [3] [4] leads to a digital representation of places, resources, and other information and is currently being discussed, tested, and prepared for industrial use. **AR applications trigger questions about new patterns and forms of human interactions with their situational (work) contexts through intermediaries such as**

AR-compatible devices [4][5]. Despite the increasing availability of AR-compatible devices such as smartphones, tablets and smart glasses, AR solutions for industrial use cases have not yet gained widespread acceptance. One problem is that advertising is seen as unrealistic and leads to exaggerated expectations; at the same time, the benefits do not yet seem to be truly tangible [6].

Promotional videos are a powerful and creative tool for accelerating new ideas, simulating new technology, and illustrating use cases and concepts, especially for dynamic events such as how people interact with objects and technologies [7]. Nevertheless, they also represent idealistic notions of the interplay between people, technologies, objects [8]. In the case of industrial applications, the AR industry focuses on business-to-business concepts, which means that promotional videos mostly address the concerns of a management team rather than the interest of employees who should work with AR solutions [6].

When it comes to understanding and modeling users' behavior in anticipated situations, the determination and description of users' worlds with their evolving contexts and situations has been understood as 'user configurations', i.e., assumptions about users that are based on unconscious stereotypes and ideas. These user configurations are inscribed into technology design so that they will later determine users' agency when dealing with the technologies [9]. In this paper, we focus on the hidden, indirect, and unsystematic sources for creating such user configurations through the articulation of AR promises in commercial YouTube videos. The relevance of identifying prevailing user configurations emerges from the observation that the imaginations of designers, users, and other stakeholders vary when it comes to user characteristics, use contexts, and the affordances of technologies.

We argue from an interdisciplinary research perspective from social and computer sciences that commercial YouTube videos on industrial AR contain consequential assumptions about workers within the manufacturing and construction industries. Investigating commercial YouTube videos through this interdisciplinary lens allows us to expose the promises of industrial AR applications, the prevailing user configurations, and the developmental expectations that are implicitly addressed to and by AR developers[1], cf. [10]. The results show how commercial videos situate AR technology, its users, and the future worlds of construction sites by reporting techno-euphoric promises and imagining use cases. Based on our findings on the articulated promises and expectations about the affordances of AR technologies, we additionally found two prevailing imaginaries about AR users: "Experts in situ" and "smart dummies." Perceived as experts in situ, AR users can efficiently solve problems through new learning strategies and supported by information visualization. In contrast, workers are presented as inexperienced and unskilled but enabled to work via AR. We label the latter as smart dummies.

We argue that the potential of AR for construction is not yet clarified. It requires overcoming the notion of "one solution fits all." We found a set of promises of AR use that indicates a need for design in relation to specific work requirements, and possibly new risks.

From our interdisciplinary point of view, joint research of sociology, Science and Technology Studies (STS), and Human–Computer Interaction (HCI) can contribute to a more holistic understanding of construction workplaces and contribute to responsible and socially robust AR applications.

Our paper aims to examine the promises of AR in 30 commercial YouTube videos for the manufacturing and construction industries regarding assumed application benefits and to compare these with the conditions in construction work. Commercial videos are often used to familiarize potential buyers and users with new

[1] Liao highlights how the marketing industry as well as AR development have influenced each other by showing the interplay between anticipated uses of AR designers and industrial needs of marketing companies [10][4][10].

technologies and their possibilities. At the same time, presenting visions of future applications is a way to configure users, define appropriate social worlds of technology use, and put forward developmental expectations. In the next section, we present our theoretical background and related work on user configurations, i.e., implicit user representations, and how YouTube videos are used as design resource. Section 3 describes our methodology of video analysis by following the criteria of Grounded Theory Methodology (GTM) and Situational Analysis (SA). The subsequent sections present the contributions of our paper: First, we untangle the promises of AR for manufacturing and construction work (Section 4.1). Second, we present two (envisioned) configurations of AR users (Section 4.2). Third, we discuss how YouTube videos reconstruct developmental expectations and, thus, can be used to shed light on discrepancies between technological development and foreseeable requirements in construction work (Section 5). Finally, we conclude with a reflection on our work and implications for further research.

2 RELATED WORK AND BACKGROUND

Recently, much research has been conducted on how AR can be used as a tool for marketing and advertisement [11], [12], [13], [14]. In contrast, we bring in the complementary perspective of examining commercial YouTube videos about AR applications. By analyzing these commercials, we aim to reveal the promises of AR applications for manufacturing and construction work from mainly information technology (IT) companies and marketing points of view, and to analyze prevailing AR user configurations in the commercials. We build on previous work in sociology, STS, and HCI.

The use of AR devices has been amplified in the recent years with the advance of the respective software and hardware solutions. Research has explored different industrial use cases such as assembly instructions [15], wiring processes [16], and human–robot collaborations [17][18]. Despite the interest of different industries such as manufacturing and construction in conducting research in this field, the majority of studies evaluating this advanced technology for different workplaces are still limited. AR researchers agree that among the aspects that challenges the use of AR technologies within real life contexts are the following: tracking conditions (hands, bodies, objects), display resolution, and portability of the equipment [19]. Furthermore, the lack of ubiquity and interoperability between various devices such as computers, mobile devices, and servers, is an obstacle when implementing immersive applications, since data exchange might be necessary [20].

There is an intense discourse about use cases and potential applications surrounded by assumptions and imaginations about how AR will be used in the future and how it will change industries, contexts, and people [6]. There are few studies on the relation between AR devices, work contexts, and users' preferences, competences, and resources to use this technology beneficially [5]. It is still an open question to what extent AR can be an everyday tool for construction workers employed at different sites.

In the following, we outline established tools for user involvement in HCI. We then turn to work in STS and sociology to describe the significance of user configurations. Finally, we refer to video analysis in STS and HCI to illustrate how videos can serve as a design resource for researchers, designers, and developers.

2.1 User Involvement in Interaction Design

For the HCI community, participatory design has been one of the main tools used to include users in the loop. It considers the user as a source of information and expertise that would benefit the design process when shared with designers and researchers [21]. As studies in this area evolved, different approaches were developed to actively include users with different characteristics. These approaches to participatory design vary considerably depending on the context and the different stakeholders that need to be involved to ensure useable and useful technologies. With a different perspective, there are model-based approaches that offer a more systematic way of design conception, related mainly to software engineering pillars [22]. In the mixed reality domain, combining both participatory design and model-based approaches is an advantageous way to support the design process. Moreover, users can experiment with new technology while providing feedback on their technology experience [23].

Personas are another tool widely used during interaction design. It works by describing the use of technology as a profile. This approach includes as many details as possible from their intended scope to write a storyline of the use case. Personas provide an idea of the possible design flaws by describing the use cases in action [24], and can also be adapted using the concepts of participatory and model-based approaches. Much has been discussed about the best practices for creating personas within design processes [25], and how to include users in this process. In addition to these explicit efforts to identify user needs, innovation processes always include implicit assumptions about the user. The sources of these notions are manifold and their contribution within the design process is not always transparent. In this sense, our work relates to implicit assumptions about users that emerge from commercials. Therefore, we turn our attention to indirect, unsystematic sources for creating user imaginaries rather than the direct and systematic methods for anticipating future technology users.

2.2 Configuring Users

In STS, the research interest lies in explicit practices of information gathering, e.g., with personas, and in implicit user “configurations”[2] [9]. We are interested in the latter, i.e., hidden assumptions about users merely based on unconscious stereotypes and ideas [9], [26], [27], [28], [29]. Such biased perceptions can prove momentous under conditions of real social situations. The focus on social situations and the different ways they define everyday practices, social relationships, and their props (including technical ones) became significant in sociology with the works of ethnomethodologists Goffman (1964) and Garfinkel (1967), cf. [30]. Special interest lies in “moments of disruptions” within situations, e.g., when AR glasses on construction sites require behavioral and infrastructural adjustments [9], [30], [31]. The theoretical lens for studying (disruptive) social situations is the symmetrical consideration of technical, human, and situational elements [9], [31], [32]. Social situations shape technological developments, and, at the same time, technological innovations affect users’ worlds [26], [33], i.e., the evolving interfaces between humans and technical systems configure users and re-distribute agencies, scopes of actions, restrictions, and control [9]. Schatzki [34] refers to “material arrangements,” i.e., “a set of interconnected material entities … that can be segregated into … humans, artifacts, organisms, and things of nature” (p. 129). He expands this perspective with the “practice-arrangement nexus.” Practices involve multiple human actions that are organized by understandings, rules, and narratives [34]. In our case, manufacturing and construction activities such as assembly or inspection processes are considered as practices.

AR applications for construction are mainly developed and designed by software and IT companies without much input from the construction sector. Designers see themselves tasked with gathering information on the actual use cases, users' needs, and characteristics. During the technology design process, they anticipate

[2] In STS, additional terms are used for assumptions about users, e.g., user representations [27][29] or user images [39]. We use the term user configurations by Woolgar [9].

different use cases, use contexts, and users. As a result, through defining the scope of use, different user configurations emerge that can be described as specific assumptions on user worlds including predicted user preferences, characteristics, competencies, and motives [35]. These implicit user representations are translated into technical choices and artifact design and create tools and technologies that configure users and make certain actions and usage patterns more likely than others [9], [28], [35]. Such inscribed assumptions about users and technology affordances gives the intended user "instructions" [36] or "scripts" [35]. Therefore, user configurations refer to the process of defining, enabling, and constraining users [9]. The investigation of how users are configured within AR design processes is expanded by the consideration of "interobjectivity," i.e., technical and other elements in situations that interact with each other [9], [32], [37]. Taking this into consideration means that we as researchers focus on how multiple elements beyond "the human" and "the technology" contribute to certain user configurations.

The creation of users or user representations is a complex activity of collecting, comparing, and prioritizing relevant information on users and their relation to new technologies [38]. Information gaps are often filled with explicit or implicit investigations of user worlds, e.g., market research, observations, product testing, and generalized assumptions about users and construction workers [39], [29]. These more or less well-founded assumptions about users merge into user configurations and set rules. There is much research on how inadequate assumptions about users are inscribed into technical design choices and how these can lead to conflicts or disruptions when users interact with new technologies [9], [37], [39], [29], [40].

Fischer et al. [39] investigate the practice of configuring users and their functions within the technological design process of robots. The authors shed light on the political dimension of implicit user representations as they could function (among others) to downplay the interests of others. For example, the routinely used demarcation between (technical) experts and laypersons leads to the assumption that experts' concepts of technological design and use are more legitimate than those of the users, even if they are also experts in their fields.

New research on user configurations focuses the attention on the evaluation of these conflicts as a "design resource," showing that the development of useful technology is also achievable without contact to future users [41]. Within this paper, we will not discuss the broad repertoire of explicit and implicit user representation [29] but investigate specific sources and carriers of implicit user configurations such as commercial YouTube videos.

Hyysalo and Johnson [38] identified several sources of user representations from which two are relevant to our analysis. First, designers rely on previous product designs and "pre-formulated solutions." In the AR field, these are coming from applications in medicine, military, gaming, commercials, manufacturing, and others. The second source is traditions and engineering ideologies, i.e., user configurations evolve from the professional background of designers' visions and traditions. Moreover, organizational requirements can lead to specific assumptions of the future user [38]. The study of Evers et al. [42] shows that developers in Western countries (i.e., Germany, Great Britain, Sweden, the United States) hold ambivalent understandings of the potentials of wearable computing. They are being conscious of the importance of involving users and their interests, at the same time, they are following a "solutionism," i.e., that any (social) problem will be solved by technological innovation and their evolving control structures [42], [43], [44]. For the debate on the democratization of technology design beyond "technosolutionism," see the work of Lindtner et al. [45]. Given this background, we are inspired to focus on the non-obvious and implicit user configurations in commercials.

2.3 Video Analysis as a Design Resource

There are video analyses that investigate YouTube videos to understand specific interaction contexts of technology use, such as touchscreen use of people with motor impairment [46], children's use of tablets [47], or autonomous and assisted driving [48]. These studies use non-commercial YouTube videos to fill information gaps about users and technology interaction contexts. In this regard, analyzing videos is a conscious "tool" – like user involvement or the use of personas. Videos are not supposed to be used as a primary source of knowledge about the users, but they can offer advantages when trying to frame the scope of a use case and can help to bridge the gap between abstract and detail [49], especially for designers who are unfamiliar with the practical context for which they develop technology applications. Video material can be accessed as many times as needed, and in an early stage in the design process, it allows one to understand how tasks are executed in a specific work process. A researcher looking for information on characteristics of AEC can acquire knowledge about construction processes without entering a prefabrication or construction site. Videos further provide the possibility that the audio is translated or subtitled, facilitating access to various materials.

We focus on commercial YouTube videos that carry implicit and unsystematic assumptions about users and use cases that fit to a varying degree to the working conditions on constructions sites. We argue that commercial YouTube videos can be a design resource as they reveal tacit assumptions about users and work contexts. They not only offer visions of future uses but also locate the technologies in future (working) conditions through supposed user needs and implicit rule settings. The idea that advertisements contain "technological imaginaries" is not new. In commercials, "speculations" about the use of technology arrange a respective field with their activities, people, and materials. As mentioned before, an important consideration, when analyzing situational requirements for technology use, is an investigation of disruptions that occur when technical products are staged within social situations such as homes, or in our case, manufacturing or construction sites [50]. Similarly, the YouTube video analysis by Marres [30] emphasizes how self-driving cars "de-stabilize and disrupt" the social situation of a street. By applying SA (cf. Section 3), she reveals another level of abstraction insofar that she highlights the involvement of non-human elements, digital infrastructure, and other situational elements.

When looking at all the methodologies and concepts mentioned, we believe that commercial videos are interesting data of investigation for both the social sciences and the HCI community. Each one has their own approach for defining and studying users, and our research aims to highlight the role such videos play for piloting and developing AR technology. First, commercials transport assumptions about users, which consequently contribute to future configuration of users, which may result in different situations of enabling and constraining the user [9].

Second, these assumptions within commercials contain also ideas of the desirable affordances of AR technology. We argue that YouTube videos on AR for manufacturing and construction implicitly involve expectations about technological development for AR developers and researchers.

3 METHOD: SITUATIONAL ANALYSIS OF COMMERCIAL YOUTUBE VIDEOS

We used a qualitative approach, conducting SA to analyze the commercial videos and to identify specific human–technology configurations and their situatedness [31]. This approach focuses on situations with their heterogeneous elements. SA emphasizes the analytical significance of the material and non-human in complex situations. Commercial videos include situated configurations in which humans, AR software, hardware, and other elements interact and create imaginings of future sociotechnical realities. With SA, we aim to reconstruct the promised assistance by AR and, thus, unfold the AR user configurations. We know that these videos aim for AR marketing, thus we expect exaggerated and simplified presentations of AR use. We argue that commercial videos represent and “co-produce” performative expectations of technologies, users, and IT skills.

3.1 Data Collection

The video platform YouTube has evolved into a “hybrid cultural-commercial space” [51] (p. 357) that describes the arrangement of user-generated content systematically interlinked with the economic interests of private users and professional collectives. YouTube has become an ecosystem in which popular culture (with its amateur aesthetic) is interwoven with professional industry practices, resulting in a powerful marketing tool [52], [53]. The data collection via YouTube was carried out using the following keyword combinations: 1) AR + [digital] prefabrication, 2) AR + Industry 4.0 or industrial applications, and 3) AR + construction. In terms of the process of theoretical sampling, we included 30 out of 56 videos in the analysis. Theoretical sampling refers to an iterative process of data collection and data analysis [31]. Table 1 describes the videos, showing only the year of publication, the initiators' business area, company size, country of operation, and the presented field of AR application. The videos are numbered from № 1 to № 30. Most of the videos were produced by software or IT companies.

The cross-influence of everyday practices and advertising strategies is apparent in the 30 commercial videos. The videos show mainly the product staging of head-mounted displays (HMDs) of established IT brands in a seemingly real work environment. In several videos, the professional product staging is the core focus (cf. videos № 12, 25), whereas, in others, the impression of amateur/end-user testing is highlighted (cf. videos № 17, 24). The average duration of the videos is 3:08 min., showing sequences of potential use cases of AR in work environments. We encountered more videos on industrial application areas rather than explicitly on construction applications. Interestingly, the different work contexts are not differentiated and become blurred. So, we decided to analyze videos on AR applications in manufacturing and construction.

Table 1: YouTube videos used in our analysis

№	Year	Business area	Company size	Country of operation	Field of AR application
1	2014	Information Technology	Medium (60)	USA/Germany	Manufacturing
2*	2015	Information Technology	Small (11–50)	USA	Manufacturing
3	2016	Information Technology	Medium (64)	USA	Manufacturing
4	2016	Independent media company	Medium (85)	USA	Construction
5	2017	Technology platform/Electrical Industry	Medium (84) /Large (2,550)	USA/ USA	Construction
6	2017	Information Technology	Medium (140)	USA	Construction
7	2017	Research Institute	Large (2,100+)	USA	Construction
8	2017	Agricultural Manufacturing	Large (20,000+)	USA	Manufacturing
9	2017	Information Technology/Automation	Small (40+) /Large (20,100+)	Germany/Germany	Manufacturing
10	2017	Information Technology/Steel Industry	Large (175,508)/ Large (104,000)	USA/Germany	Manufacturing
11	2017	Information Technology/Automotive Industry	Large (175,508)/ Large (190,000)	USA/USA	Manufacturing
12	2017	Information Technology/Aircraft Industry	Medium (50–200) /Large (141,000)	USA/USA	Manufacturing
13	2018	Information Technology	Large (11,500)	USA	Construction
14	2018	Construction/ Manufacturing	Large (nearly 1000)	USA	Construction
15	2018	Information Technology	Large (6,000+)	USA	Manufacturing
16	2018	Information Technology	Large (129,000)	Japan	Manufacturing
17	2018	Mobility	Large (395,000)	Germany	Manufacturing
18	2018	Mobility	Large (153,522)	Germany	Manufacturing
19	2018	Electrical Industry	Large (17,100)	Germany	Manufacturing
20	2018	Information Technology	Small (10–19)	Germany	Manufacturing
21	2018	Research Institute	Small (14, just the Research lab)	USA	Manufacturing
22	2018	Information Technology	Large (110,600)	USA	Other/not specified
23	2018	Information Technology	Large (6,250)	UK	Manufacturing
24	2019	Construction	Medium (200)	USA	Construction
25	2019	Information Technology	Large (6,000+)	USA	Manufacturing
26	2019	Information Technology/ Automotive Industry	Large (270,000)/ Large (120,726)	France/Germany	Manufacturing
27	2019	Electrical industry	Large (400+)	USA	Manufacturing
28	2020	Information Technology	Large (6,000+)	USA	Manufacturing
29	2020	Information Technology	Large (6,000+)	USA	Manufacturing
30	2021	Information Technology	Small (25–50)	UK	Construction

Note: The video numbers are linked. Two descriptions if actors have cooperated. *Video № 2 is no longer available but here is a comparable video.

3.2 Data Analysis

The video analysis was conducted using the MAXQDA software, which is designed for computer-assisted qualitative and/or mixed-method analysis [54]. The data analysis process follows an iterative research program of collecting coding, annotating, and mapping YouTube videos based on the guidelines of GTM [55], [56]. The purpose of this approach is not the quantitative reproduction and repetition of promises or contents but the uncovering of the stories and situations within the videos. The analytical strategy is comparative coding, which means that the videos are analyzed based on keywords and/or -phrases. The videos were directly coded without transcription by a single coder. In the analysis process, the keywords were developed from “in-vivo-codes” to analytical “concepts” and interpretative “categories**.**” Interpretative categories refer to different imaginaries, the situatedness of portrayed use cases, conceptual contexts, and patterns of interpretation expressed in the videos. The interdisciplinary teamwork consisted of a joint reflection of the categories. Regarding our research interest on promises of AR assistance and AR users, we elaborated the following analytical concepts on the technology promises currently articulated by the initiators**: efficiency and productivity**; **simplification**; **user access to data and remote work**; **training and skills**; **accuracy and safety**; **consistency and resilience** (under pandemic conditions). To refine these concepts and to unfold the specific human–AR relations, we used the analytical tool of SA mapping, which allows positioning discursive elements, human and non-human activity, and thus, discovering diversities, differences, and conflicts within situations [31]. Based on our analytical concepts as well as preliminary research on the criteria of human–technology configurations [57], we enter another level of abstraction and describe two prevailing assumptions about users within the YouTube commercials to reveal the current spectrum of AR user configurations (Section 4.2).

4 RESULTS

The results of our analysis of commercial YouTube videos are grouped into two parts. First, we present the promises of assistance and worker benefits associated with AR application, see Figure 1. Thereby, we outline how specific human–AR technology relations are supposed to generate these desirable advancements. Second, we point to the ambivalent coexistence of two user configurations that become apparent in the videos. In this step, we reach another level of abstraction and use our preliminary research on the criteria of human–technology configurations [57] to describe our observations. Our interest is to highlight that apparent representational differences and ongoing debates about AR technology involve multiple assumptions about users depending on how AR technology and other elements are situated.

4.1 Promises of AR Assistance

4.1.1 Efficiency and Productivity

> “*[AR] doesn’t replace the processes that they use now, it augments them, it makes them better, it makes them faster*” (video № 11).

One of the most repeated promises in the videos refers to the increased efficiency and productivity in both manufacturing and construction. The implementation of AR is associated with cost and time savings. In the context of manufacturing, video № 12 mentions time savings of up to 25%, and the wire harness assembly[3] for the construction of an aircraft is described as “*fast as heck.*” In addition, video № 8 claims a 25–35% reduction of processing time within the manufacturing of agricultural equipment. In both videos, the companies emphasize that work tasks essentially depend on instructions, i.e., wire assembly or quality checks of vehicles.

In this situation, assembly workers are using smart glasses that are considered to be more suitable when both hands are needed to physically operate. Similar assumptions are expected for the construction context.

[3] The systematic arrangement of cables to transmit electrical power and/or signals.

Here, efficiency is mainly related to the on-time completion of buildings and fewer errors (videos № 4, 5, 6, 30). Re-doing and re-building are considered to be the most cost-intensive projects (video № 30).

Unsurprisingly, efficiency and productivity remain the buzzwords within the commercial videos, but how time and cost savings are generated by using AR is not always clear in these situations. However, video № 10 demonstrates a situation in which AR is actually implemented in a manufacturing company. They experienced an improvement of the decision-making processes that is faster via AR. Likewise, video № 15 speculates that AR will enable quick reactions to problems before they occur.

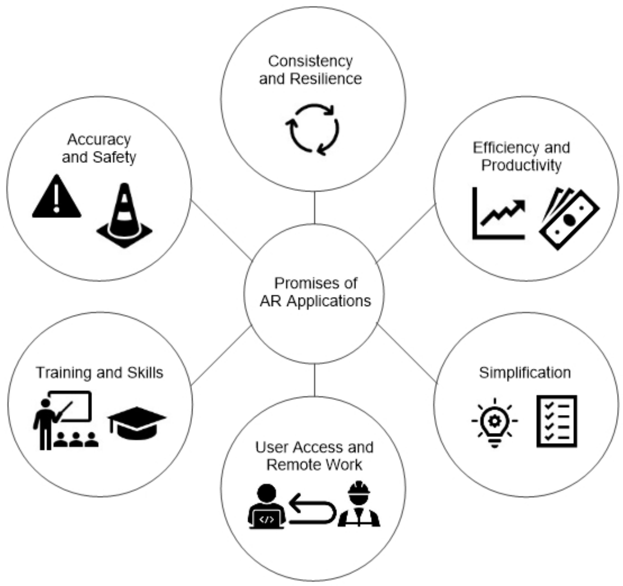

Figure 1: Promises of AR applications (own visualization)

4.1.2 Simplification

The promise of simplification relates to the diagnosis that everything has become increasingly complex such as processes, tasks, and devices. Especially in the context of manufacturing, uncertain work **configurations** are seemingly rendered manageable. AR technology is considered to serve as a connecting device that offers a more intuitive way of interacting with complex work equipment (video № 27). The objective is to "*configure everything [at the workplace] in a very simple way. Simple UI [User Interface], simple user experience*" (video № 23).

AR technology is perceived as a wearable gadget that enables workers to handle complex work situations. Interestingly, IT stakeholders note that technological artifacts are becoming more opaque, complex, and counterintuitive to users. AR technology is supposed to solve these shortcomings in technological design and to simplify the interaction with complex infrastructures. A physical layout of the environment, machine, or other objects is represented and augmented with information precisely located (videos № 1, 17, 27). AR technology thus serves as a solution for handling a plethora of complex data and situations that arise from it. The subtextual assumption is that complexity problems caused by inadequate technological / software designs could be solved by perceiving the required information via AR overlays. This implies that the implementation of manufacturing machines has not been sufficiently evaluated and the overall work situation has become opaque and critically complex. However, it is not addressed how IT stakeholders deal with these problems within the development process of industrial AR.

Another aspect is the prospect of hands-free user interface by using HMDs. Operators obtain visualized information in front of their eyes and can use their hands freely to interact with a physical object. The videos explain that this situation could support troubleshooting and assembly tasks. In the situation of wire harness assembly within the construction of an aircraft, the electricians need their hands to connect wires properly and need to follow instructions without errors (video № 12). In video № 8, a manager reports that the team first used tablets to check the quality of the vehicles. She continues that the workers were happy to use these tablets, but they dropped them off regularly or drove over them with the tractors. As a result, the IT department sought for a new hardware solution such as smart glasses.

4.1.3 User Access to Data and Remote Work

The simplification of work processes seems to be supported by an assumption that AR users will constantly have access to relevant information to perform their work tasks. Especially in situations when using AR glasses, the promise is that information is always visually present. Workers are able to consume multiple forms of data: for example training data such as images and videos explaining complex tasks (videos № 3, 26), reviews such as design safety reports, operator manuals, contractor reviews (video № 7), machine mechanics such as flow rates, tank levels, the status of valves, advanced diagnostics such as real-time trends, or inspection notes (videos № 19, 27). This availability refers to the interaction between users and a digital data archive, i.e., including information about processes and machines that are pre-known and, thus, digitally storable and processable.

This advantage is also considered for construction. In video № 13, several construction workers experiment with two helmet-mounted displays on a construction site. They are impressed by AR and speculate that coordination would be the main benefit because they can constantly compare the digital building model with the status on-site:

> "*On a blueprint, you don't have 3D … you can't see layers on it. You can only see like an overhead, looking down and there is usually a lot of lines running above or below each other … the general area where it's supposed to be – but you don't have an idea of elevation*" (video № 13).

In the case of complex problem-solving tasks, when required information is missing, HMDs and handhelds are presented as an assistive medium to connect operators with experts (video № 25). In the case of a technical issue, the problem can be immediately shared with someone who can solve it (videos № 18, 20, 23, 29).

In this situation, it is not clear why AR technology is more beneficial than other technologies enabling remote work. We assume that they refer to the assumption of a "*shared view environment*" (video № 25) when remotely operating experts may experience the same situation as the workers on the shop floor level or construction site. It shows further that the term AR is associated with remote work even if the information is not visualized via AR devices.

4.1.4 Training and Skills

> "*AR is fundamental to the worker of the future, you could be servicing a car today and a jet engine tomorrow, it really has this potential to transform workers and elevate their skill levels*" (video № 5).

This statement shows both the assumption that everyone can be employed regardless of one's education and the required tasks as well as the upskilling of workers. The structural challenge in manufacturing and construction is the shortage of skilled workers. In video № 25, an increase of over 2 million unfilled jobs in manufacturing by 2025 is expected. In the videos № 15, 25, 27, and 28, the skill gap is explained, on the one hand, by the retirement of qualified, specialized, and experienced employees and on the other hand, by the lack of training strategies for new workers. The same is expected for the construction industry (video № 7). AR is considered to compensate for the lack of required skills insofar that it will collect, document, and provide technical know-how and hands-on experiences. AR is promised to provide a digital, "*shareable expert archive*" to which workers have access at all times (video № 25). The following statement shows an understanding of skills as storable and consumable goods that can be easily transferred to everything and everyone:

> "*Companies will need to slow the skills drain, maximize current skills, and refill the skills reservoir. The answer lies in industrial augmented reality … which is a game-changer when it comes to closing the skills gap*" (video № 25).

For both contexts, manufacturing, and construction, we identified three major assumptions on users' skills in the envisioned interaction with AR: 1) skills are storable and transferable to digital archives, 2) everyone from (un)skilled shop floor to construction workers can consume these skills, and 3) everyone will be upskilled to experts in situ (videos № 5, 15, 20, 23, 25, 28).

In video № 20, the IT consultancy imagines that "*everyone becomes an expert*" who solves problems faster and more efficiently and with less risk. The video situates AR technology as a medium for remote collaboration, that supports a labeler expert with 30 years of knowledge to guide other inexperienced shop floor workers. Since the 1980s, sociological research highlights the relevance of (tacit) skills, competences, and work experiences in working with, and alongside, digital technologies [44], [57], [59]. So, the observed assumptions on users' skills are problematic in two ways. First, they lead to the conclusion that users do not need special know-how to successfully perform their job, as the following statement demonstrates:

> "*What you have to do is just to operate. Not understanding how the application works"* (video № 23).

Second, tacit knowledge and implicit work experience and their relevance for coping with work situations are underestimated and the orienting function of system knowledge, which is necessary to benefit from detailed information, is ignored.

Another promise is that AR will change training practices. Complex information can be easily visualized via AR. In video № 17, a training supervisor speculates that trainees and students will no longer need a physical object in front of them to understand machine processes in depth. Besides a simpler training process, AR is also imagined to reduce training time: The acquirement of "*deep procedural know-how and hands-on expertise*" may be highly time-consuming, so the learning process will become faster and "*AR [will] compresses the timeline for human understanding*" (video № 28). It is not clear how these time savings are achieved, we assume that the possibility for self-training without an experienced supervisor could contribute to time savings in general, as it is reported in video № 26.

4.1.5 Accuracy and Safety

The videos further propose an accurate, error-free production workflow by using AR (videos № 7, 13, 14, 20, 23, 30). Regarding accuracy, there are several situations in which the human operator is seen as the error factor, or AR technology is presented as supportive in work processes by reducing novice errors (videos № 9, 14, 23, 25). Especially in the context of construction, the promises of accurate workflows and first-time quality are apparent (videos № 7, 13, 14, 30). AR seems to be particularly beneficial in the inspection process of construction sites and buildings that is otherwise time-consuming and labor-intensive. AR-driven quality inspections require only one person who compares the virtual data with the emerging building (videos № 7, 13).

The promise of improved safety is more apparent in the videos on AR applications for construction (videos № 4–7, 30). In video № 7, the narrator suggests that serious concerns could be identified and directly shared with those who can respond. However, it became not clear how AR would improve workers' safety and health. The typical risks of accidents on construction sites, bad weather, limited visibility, and unforeseen breakdowns are not addressed in the videos. In one video (№ 4), a worker is shown who is not allowed to wear AR glasses on the construction site for safety reasons. This issue probably occurs due to the lack of required safety standards for handling HMDs as many building regulations still do not permit these on construction sites.

4.1.6 Consistency and Resilience

With the onset of the Covid-19 pandemic, technology companies were also experiencing production delays and supply shortages. The comparison of videos № 28 and 29 shows that AR solutions are now more strongly perceived as contributing to ensuring production continuity: Video № 29 shows sequences of deserted production halls and frontline workers who ought to work at a safe distance from their colleagues. The atmosphere is gloomy, but it shows that human operators are indispensable in seemingly highly automated manufacturing processes. As soon as AR technology appears, the atmosphere changes for the better. Whereas previously skills and knowledge transfer were playing a significant role in remaining competitive (video № 28), the focus is now shifting to maintaining production, adapting to change, agility, and preparing employees ("being prepared") for an uncertain future. Employees' skills and competencies are still relevant but now to generate resilient workforces to guarantee continuous manufacturing. The implicit promise is that AR connects humans who may not be in one place. Knowledge and information are distributed between multiple entities to ensure continuous and flexible value creation. AR technology seems to be the key technology to restart business and production under pandemic conditions.

4.2 Creating Two Prevailing User Configurations

Throughout the analysis of the promises of AR, two user configurations become apparent. In the following section, we unfold these configurations based on the assumption that skills, expertise, and hands-on experience can be easily codified and digitally stored (cf. Section 4.1.4). The configuration of AR users ranges from "experts in situ" to "smart dummies." Our preliminary research on the criteria of human–technology configurations **[57]** serves as analytical glasses to describe the observations while the findings derive directly from the empirical data. The term "experts" is directly mentioned in the video, whereas the term "smart dummies" is derived from our analytical reflections. We enter another level of abstraction and describe two prevailing assumptions about users within the YouTube commercials.

The prevailing imaginaries about AR users evolve from a shared perception, mainly among IT companies, about the current challenges in manufacturing and construction. These industries are affected by skill shortages also due to the retirement of experts. Knowledge, skills, and hands-on experience associated with human resources seem increasingly scarce but are the key prerequisite for handling complex technical systems. One alternative for this problem seems to lie in specific human–AR–technology relations (cf. Table 2). This assumption is supported by the common argument in the videos that skills and experience are storable and transferable to AR devices. AR user configurations become apparent in situations, when – on the one hand – future users of AR are perceived as experts in situ, who can efficiently solve problems through both new learning strategies and new information visualization. On the other hand, workers are presented as inexperienced and unskilled but enabled to work via AR. Smart dummies refer to workers who physically perform the tasks while AR carries/retains the required knowledge. Interestingly, for both user types, the expert and the unskilled, the same technological device is promoted as supportive. The coexistence of the two user configurations within the empirical material is ambivalent. Although in both imaginations AR technology is intended to visually support the user, each of the two envisioned user roles will create very different implications on the workplace (design).

According to the assumption, AR users who are experts in situ will become virtually augmented problem solvers who are always able to consume and then interpret the information transferred. If the increasing complexity at the workplace requires specialized knowledge as in cases of technical problems or breakdowns, the workers will receive support from an expert via remote collaboration. The promise that everyone becomes an expert through and with AR technology suggests an upskilling of the worker. First, they receive required expert knowledge via AR and second, they become experts faster because learning processes and training are simplified, and hands-on experience is acquired more quickly via AR training. AR is seen as a tool that simplifies or bridges the ever-growing complexity of tasks, processes, and machines in manufacturing and construction.

According to our theoretical underpinnings, we argue that the developments such as the Internet of Things (IoT) or cyber-physical systems that aim to multiply connect physical and digital components, will lead to new problems regarding the interaction between multiple, heterogeneous elements in a situation. Labeling AR as a tool comparable to a hammer implies that the user is still in charge, but human control in association with smart, interconnected AR technologies is shifting to networked **setups** of machines, data, soft- and hardware. The resulting interobjectivity of technologies means that the networked **setups** remain opaque to users [57]. Without a transparent organization of the delegation of responsibilities, agency, and information within human–technology relations, there is a risk that humans may not be able to intervene in typical risk situations, i.e., if the data availability breaks down, the data infrastructure is not adapted to the conditions on-site, or the underlying data or models do not fit to actual work tasks.

The configuration coined smart dummies refers to designers' expectations that in the future everyone will be able to work without special skills or training – irrespective of whether on a shop floor or a construction site. The assumption is that workers should only operate without having to think about the functionalities of digital devices such as AR glasses and underlying software infrastructures. This perspective promises that skills and experience can be replaced by the human–data–glasses configuration with the worker running the risk to become a human mock-up rather than a value-adding subject within production processes. The role of implicit skills, tacit knowledge, and long-lasting experience is undervalued or ignored in all the analyzed videos.

Table 2: User configurations in commercial YouTube videos

User configuration*	Experts in situ	Smart dummies
Notion of knowledge, skills	Digitally storable, transferable; human acquisition (upskilling)	Digitally storable, transferable; human consumption
User in persona	Problem-solver, technical supervisor	Just operator, inexperienced, unskilled, henchman
Configuration of technology	AR as a tool that augments human performance	AR replaces human knowledge, experience
User experience	Simplification: in complex situation, AR assistance or connection to other experts, support	Simplification: Enabling work performance without any special knowledge; guidance
Contradictions/conflicts/risks	AR interobjectivity and human control options and needs are not sufficiently considered	AR as knowledge carrier is overrated; human qualifications such as experience, tacit knowledge and implicit skills are underrated

Note: The table structure is based on Kropp and Wortmeier [57]; * the term "experts" is directly mentioned in the video, whereas the term "smart dummies" is derived from our analytical reflections.

DISCUSSION: EXPECTATIONS ON TECHNOLOGICAL DEVELOPMENT

Analyzing the YouTube videos portraying expected use cases related to the construction and manufacturing industry allowed us to typify some promises probably made from the marketing units. They transfer expectations coming from technology development and the hope to implement AR technology in manufacturing and construction. We discussed how these commercial videos may influence the expectations on AR technology from general public, workers, and other industry stakeholders. Workers in the construction industry might not be familiar with AR technology yet. In general, there is a tendency that when people think about immersive technology, they might picture a futuristic view and possibly a tool that will facilitate and modernize their life. These associations can be evoked by promotional videos and sometimes serve as sufficient reason for decision-makers in companies to pilot these new technologies, as observed during our field work in the construction industry [60].

Our analysis confirms the findings of Liao and Iliadis [6], who highlight the pivoting process within the AR industry and how visions of consumer AR evolved to industrial AR with the promises of safety, efficiency, and scalability. The authors point to powerful advertising that contains and stabilizes the visions of AR and sparks interest within various industries. However, if the high expectations of AR solutions raised by commercials prove to be unrealizable, then the demand may sharply decrease [6].

Technologies do not effectively improve the overall work situation if undesirable work conditions occur because the affected people are not included or inadequately envisioned during the technology development process. User configurations are powerful and can set the stage for undesirable work conditions. For this reason, it is essential to unfold the stream of visions to discuss the future of construction work and to focus on the needs and perspectives of construction workers.

We as researchers should consider the "disruptions" in social situations and investigate the "silent" aspects in the videos. Based on our experience and on research of new technologies that are aggregated to workplaces, we expect that the AR development will face the following key issues: Sociotechnical interplay between users' skills and AR technology, individual adjustments for workplace, the gap between commercials and real applications, and safety regulations for construction settings. Moreover, we emphasize that involving on-site-user involvement and open innovation procedures are still crucial methods for generating socially robust innovation.

The sociotechnical interplay between users' skills, experience, and AR technology: The simplified visions of human–AR relations within the videos call for a sociotechnical understanding of the interplay between users with their individual characteristics and AR technology that is more than a simple tool. On the one hand, skills and technical know-how are presented in the videos as valuable, essential resources for successful performance within manufacturing and construction. On the other hand, work processes and required knowledge are suggested to be easily digitized. The discussion of tacit knowledge and implicit competencies is completely lacking or deemed irrelevant. However, this underestimation of skills is precisely why successful technology adoption so often fails [37], [57]. In present research, the discourse ranges between a presumed upskilling (upgrade of skills) and the risk of deskilling[4] due to the increasing complexity of "smart" production systems [61], [62]. Well-qualified and well-practiced workers will be even more required in digitized workplaces [57]. AR technology does not substitute work experience and/or the practical/hands-on and embodied training of workplace specific skills. Instead, the use of AR requires additional competencies to interpret, assess, and evaluate these technologies for one's own work situation.

We critically assess the implicit mind–body dualism within the commercial videos and argue that tacit skills and experience are relational to the human mind and body, technology, and work situations [37], [57], [59]. Furthermore, there is a risk of prioritizing skills that can be easily codified and digitally stored. The strategy of downplaying certain aspects within the anticipation of users' worlds is addressed by Fischer et al. [39].

Another aspect is that, on the one hand, AR as a knowledge carrier is overestimated, and on the other hand, AR is underestimated in its interobjectivity, i.e., the multiple interactions with machines, technologies, data archives, and others. Even if AR technology will provide visual assistance, we should consider the "new" skills and experiences workers need to interact with AR interfaces (and via AR with various heterogeneous objects). The promise to easily transfer essential knowledge to technical devices without providing for appropriate skills and work organization is in danger of leading to new risk situations where workers need to be re-educated and re-trained. Technological "solutionism," the suggestion that any problem will be solved by technological innovation, is an old fallacy [42], [43], [44]. Especially when the identification and elimination of construction faults and risks is delegated to technology, as promised in some videos, this situation requires workers who can critically reflect and evaluate technical messages and data integration from various sources.

Individual adjustments for workplace characteristics: During the analysis, we encounter the concept of work representations that especially focuses on work processes, tasks, and conditions [63]. Already during the data collection, we realized that the envisioned workplaces in manufacturing and construction are not differentiated. Differences between conditions of manufacturing work and construction work, especially when it comes to the individuality and complexity of construction sites and their climatic exposure, are largely blanked out. The videos show multiple AR use cases for multiple workplaces. Paradoxically, commercials that aim to address

[4] By deskilling, we mean the process of workers or professionals becoming less competent over time or losing skills through the implementation of digital technologies [64].

stakeholders in construction present industrial tasks such as pick-and-place assembly processes. Rain or dust clouds are missing from the videos. We also observe that workplace specifications are not only omitted, few video initiators also maintain that with AR anyone can work in any industry. This assumption shows the scope of how pre-formulated solutions and strategies [38] by IT companies and/or designers spread over different work contexts. AR promises for the manufacturing industry are also expected for AEC and vice versa. Addressing “blurred target audiences” [8] in promotional videos is probably related to the current need to find appropriate enterprise/industrial use cases [6].

The gap between commercials and real applications: One of the issues that can cause this disparity between what is shown in advertisements and the real application is that, very often, the buyer is not the person who will use the application. Personas are a good strategy to shape the user profile of a product, but they are based on assumptions of the user that are not always correct [65], especially when the advertisement does not target the final user itself, but a company who might be interested in the technology for their employees to use. Even further away, the target can also be focused on these company’s customers, who could be more interested in the company’s product because they are using new technology. For this reason, the gap between the final user, the interface designer, and the marketing department can be bigger than in other industry sectors.

We know that advertisements do not have to exactly portray reality, and in most cases, it is not a problem that the promises shown are not the same as the product sold. As an example, we can take a drink advertisement that promises to make you fly when you consume it. In this case, the target audience is aware that it will not happen in reality; the ones who create the advertisement can count on the customer experience as people who consume drinks to make sure they know the commercial is an exaggeration. For AR though, this scenario is not exactly the case. Since the devices that are produced to run AR applications are not yet widespread, people do not have the background that is needed to know what they can expect from it. In this sense, it is to be expected that the popularization of this technology will diminish this gap, but as researchers, it is also important to bring this discussion to the community. We should investigate what is the role of the users and what we should consider when developing use cases that are focused on a specific field. It is important to consider the expectations that we can see from the concepts in the commercials, as well as what would be the possible issues of AR applications. The gap between commercials and real-world applications also arises from the various human actors and institutions that cooperate (or not) with each other, equipped with different interests, assumptions, and powers, see Figure 2. Technology design is always a sociotechnical negotiation process.

Safety regulations for HMDs on construction sites: Video № 4 emphasizes that workers interacting with HMDs are currently not allowed on real construction sites due to safety issues. The question arises how the interaction with AR changes the situational awareness of workers? Construction sites are chaotic and change day by day. How will AR improve safety in this unstable work context? The paradox is that AR marketing for construction use cases promise higher safety standards but do not consider the specifications of construction sites. We argue that if research focuses on improved safety for construction workers, it will be crucial to investigate the “new” risks that evolve from implementing the use of HMDs and AR glasses on site.

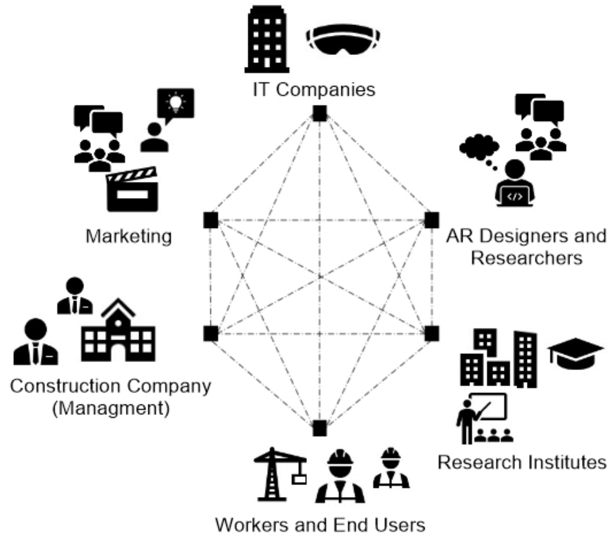

Figure 2: Human actors **within sociotechnical negotiation process** (own visualization)

5 STUDY LIMITATIONS AND REFLECTIONS

Our empirical results should be considered in the light of some limitations. We selected the analyzed videos in the spirit of the theoretical sampling of GTM, which refers to an iterative process of data collection and data analysis to the point when a status of theoretical saturation is reached. Following this approach means that we, as an interdisciplinary research team, discontinued further data collection as soon as the collected data stopped revealing new conceptual perspectives.

Furthermore, we decided to conduct a qualitative research design to explore the implicit assumptions about the relation between users and AR technology. Analyzing the specific situations within commercials allowed us to observe different heterogeneous elements that contribute to the creation of user imaginations. In the future, our study could be extended by using semiautomated methods for textual and visual data to achieve a larger sample size, cf. [30].

The results of this study should be supported by further research within HCI, sociology, and STS. We would like to advocate the systematic analysis of commercials as an interesting add-on to the methods toolbox of researchers interested in socio-technical imaginations and user configurations.

6 CONCLUSION AND FURTHER RESEARCH

IT companies initiate videos to promote future applications of AR for manufacturing and construction. Our video analysis of 30 commercial YouTube videos shows that the key promises of AR implementation refer to efficiency and productivity; simplification; user access to data and remote work; training and skills; accuracy and safety; consistency and resilience. Our main outcome is calling attention to the fact that the videos articulate ambivalent assumptions about industrial AR users: they are sometimes portrayed as experts in situ and sometimes as smart dummies. Based on this, we explore what underlies these assumptions, how they may influence people’s and companies' perception of potential AR users, and what the consequences may be. The ambivalent coexistence of promises reveals a need for rethinking how information is presented in AR applications and to better consider the specific work requirements and possibly new risks on site. Moreover, as digital devices are capable of directing action in ways not always conducive to users or necessarily in line with their desires and needs, we advocate for greater user involvement, especially when it comes to designing technologies for workers with already significant burdens.

In terms of design processes, the absence of direct user involvement is a well-noted issue [66], and we full-heartedly agree that direct contact to end users' needs to be at the core of user-centered HCI research. At the same time, we found it interesting to expand this knowledge by studying artifacts that involve implicit assumptions about future AR users, and expectations about technology developments, in our case, YouTube commercials. Studying commercials helped us to disentangle visions, hopes, and expectations of stakeholders that are not the users themselves but that certainly seek to shape and steer the future of this area. Of course, critical reflection is needed as these expectations might or might not be accurate and adequate. Yet, exactly this reflection can open new perspectives and reveal new risks that we might face in the future. While our work focused on AR applications in the manufacturing and construction industry, we are confident that similar endeavors could unveil interesting insights into other areas of HCI research as well.

Interdisciplinary research within HCI can contribute to a socially more robust understanding of construction workplaces and the needs of responsible AR applications. Due to our special research interest in construction workers and their characteristics and competencies, we focus mainly on the sociotechnical construction of skills and experience in the videos. Key topics such as efficiency, productivity, and remote work – to name only a few – require additional theoretical and analytical attention. Further research addressing the "power" and "performativity" of commercial videos, should integrate other qualitative methods into the research design, such as interviews, to identify the trajectory of commercial promises and semantics within a particular field such as manufacturing industries or AEC.

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DISCLOSURE STATEMENT

The authors report there are no competing interests to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available at the platform YouTube. The links to the respective videos are in Table 1 within this publication. The authors saved the videos for scientific purposes. We offer an Excel sheet including the list of the 30 commercial YouTube videos with information on year/title/duration/initiator/type of initiator/link/keywords in search/field of AR application/short description/notes on each of the respective videos: Ann-Kathrin Wortmeier, Aimée Sousa Calepso, Cordula Kropp, Michael Sedlmair and Daniel Weiskopf. 2022. Replication Data for BauHCI Video Analysis. In DaRUS. https://doi.org/10.18419/darus-2117

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