Drywall Installers' Work Demands – Tackling between Normal Duties and Absurd Challenges

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ABSTRACT

When developing the construction industry, also the work at the construction site needs to be understood. Moreover, the construction work needs to be developed as part of the developing of the construction industry; the work at the site does not take place in isolation. The worker level, investigated from the worker's perspective, is mainly missing in the studies about the construction industry. In this study, the demands of the drywall installers are analysed according to Core-Task Analysis. The demands are classified between dynamics, complexity, and uncertainty related demands. Further analysis shows that the party primarily responsible for managing the demands can be also some other party than the worker him/herself. Moreover, some of the demands are out of proportion. We argue that the experience of the workers is vital for the successful construction work. The superiors often lack experience needed at the site and the workers then need to use their experience in tackling daily challenges. Especially, the experienced worker is able to compensate the deficiencies in the floorplans and construction drawings. The managing of some of the demands can be supported by providing the workers visual information. Visual information represents a means to deliver information also when the workers do not share a common language.

CCS CONCEPTS

• **Social and professional topics**;

KEYWORDS

Construction, Worker, Demands, Qualitative

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1 INTRODUCTION

The construction industry is important for the society, providing an essential part of the infrastructure in an urban environment. The industry has developed by time; the construction site has benefitted from the new technology, in the areas of building methods, materials, plant, and machinery [19]. However, the construction projects are also notorious for, e.g., increasing project cost, project delays, or loss of profit [6]. Thus, productivity development in the construction industry has stagnated in general during the 21st century, being, for instance, only moderate at its best in Finland [14]. The construction industry also suffers globally from poor safety performance, with unacceptably high accident rates [2].

Pertaining to human performance, the construction industry has been described as involving many conflicts, realised in the construction project members' performance [6]. From the behavioural perspective, problems arise because different roles have different needs – contractor's needs are related to money or profit, designer has his/her reputation related to the building as a design artefact, etc. These various needs result in problems due to poor team spirit and poor communication among the project teams [6]. Regarding contractual problems, there are, e.g., human errors and unforeseen changes, hard to consider and agree on, resulting in disputes [6]. Finally, technical problems are related with uncertainty, that is, the difference between the amount of information needed and processed. This may lead to, for example, unrealistic client expectations regarding contact duration, or late instructions or information from architect [6]. The complex and even chaotic nature of the construction projects means, for example, that no one has adequate information on the status of the design and the construction activities [8]. Accordingly, poor site management, coordination and planning have been identified as major problems in the construction projects [10].

Thus, the construction industry has been studied from many perspectives. However, the studies about the concrete work performed at the construction site have been mainly performed without asking the workers' opinions. As an example, pertaining to workers' health issues, there are a lot of studies about the ways to measure workers' physical demands (e.g., [1, 5]). Authors have found only one such study about the content of the work at the construction site with worker interviews. In this study, about the root causes for wasted efforts in construction projects [16], it was found that the main causes are related to (i) communication, as the workers tended to lack the overall understanding of the project, resulting in hurried installations and work coordination related discussions at the site. Another reason is in (ii) production planning and control, which were not detailed enough, including not updated schedules, resulting in workers jumping from task to task with a lot of emergency work. Problems in (iii) material logistics were related to material storage far away from the construction site; material was sometimes not ordered so it was missing, meaning that time was spent

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on fetching and searching for the material. Pertaining to (iv) design, there were various clashes in the design documents, such as the parts not available to the workers or design solutions, which were impossible or time consuming to implement. Finally, preparatory measures (v) such as all material movements and organising in the workplace took a long time for the workers.

Additionally, based on the subcontractor focus-group interviews, Loosemore [10] has found that the relationship between managers and workers has suffered because younger supervisors tend to rely too much on computers in communicating with subcontractors instead of having face-to-face interaction. Even if the interview participants were from the managerial level, the notice is in the worker level.

Otherwise, the workers' opinions and experiences seem to be largely unknown in the scientific literature. The worker level is important to understand the construction industry as a whole - the actual building activity takes place at the construction site. Does the worker level have the problems of their own, or at all, or are the issues at the construction site only reflections from the higher-level ones? The worker is an elementary party in the construction industry. Solving problems in the construction industry should also mean solving problems at the construction site, in the worker level.

A nationally funded, two-year research project ACTOR has been initiated, targeting to increase productivity in the construction industry through process automation. The aim of the project is to develop a feasible concept to support workers directly, by providing them with task-related and up-to-date visual information. This requires understanding the construction work from the perspective of the workers themselves. The project will utilise autonomous data collection on the progress of construction and data analysis with advanced AI approaches. These technologies will be used in supporting the actions of the individual workers. The present study is a part of the ACTOR project.

The provision of visual information belongs to visual management, the effort to manage project and people with visual cues, used also in the construction industry [18]. The main moto of visual management is to enhance the flow of information within the workplace and to remove the barriers of the flow [17].

The objective of this paper is to increase the understanding of the work at the construction site by shedding light on the demands of the construction workers, as perceived by the workers. Specifically, our study represents exploratory research, aiming to identify what demands construction work sets on workers. We chose to focus on one role only, the one of the drywall installers, to get a comprehensive overview of the demands of one role. Our general-level research question is the following: What are the work demands in the construction industry as experienced by the drywall installers? As this study is performed in a project intending to develop a concept for providing the workers visual information, the more detailed research question is as follows: What demands can be managed with visual information?

This paper presents our study in the following way: in Introduction, brief overview of the challenges in the construction industry is presented, starting from the larger-scale challenges, and following with the examples of studies focusing on the workers. Also research questions are presented. In Method, the theoretical basis, data collection methods and the way analysis is performed are explained. Results present work demands as perceived by the drywall installers, according to the predefined classification of dynamics, complexity, and uncertainty related demands. In Discussion, results are contemplated in the light of the existing literature and reclassified to facilitate further reflection. Conclusions contemplate the results, from the perspectives of the meaning of the results and of the limitations of the study.

2 METHOD

2.1 Theoretical background

We have interviewed construction workers and analysed the interview results based on the method of Core-Task Analysis [11]. It has its roots in activity theory [4] with the central elements of the actor (here, worker), the instruments (here, work tools) and the object of activity (here, building under construction) as the most relevant elements to this study. The other elements – rules, community, and the division of labour – are only dealt with if the interviewee mentioned them in the responses.

In Core-Task Analysis, the core task, i.e., the task that the worker is to perform, is defined. The task is expressed in such a high level of abstraction that the task can be defined briefly and incisively, irrespective of varying work conditions. Core-Task Analysis also includes both the demands in work, from the workers' perspective, and the psychological resources to tackle the demands. The demands are categorized to dynamics, complexity, and uncertainty related demands. Dynamics refers to temporal challenges and the dynamic nature of work, with at least partly unexpected intervening factors affecting the proceeding of the work. Complexity is related to many items in the system, with interrelations and possibly also with various levels of hierarchy. Uncertainty means the lack of information or uncertainty about the validity of it. We restricted our focus on the definition of the core task and the demands of the work.

The method has been applied in analysing work in various domains such as in piloting [13], in metro train driver's work [7] and in the management of autonomic networks [9], used as a tool to model control demands of a system [12]. The perspective of the demands is the one of the workers, based on the expressed opinions and experiences.

2.2 Participants

We interviewed 11 male Finnish drywall installers. Their average age was 49 years (youngest 26 years, oldest 59 years) with 26 years' work experience at construction sites (min 7 years, max 42 years). Three interviewees mentioned drywall installation and lower ceiling installation as their only work task whereas others mentioned also other tasks at the construction site. As education, nine mentioned vocational school in building trade and one high school, one did not respond to the question. All interviewees were members of the trade union, acquired by a contact there.

2.3 Interview

The interviews lasted 1,5 hours. All interviews except for one were performed remotely: 7 interviews were conducted in Teams meeting, 3 as telephone interviewing and one in-person. The interviews

were semi-structured; main questions were defined, and the rest depended on the response. Main themes of the interview were (i) collaboration and information needs, (ii) work challenges, and (iii) new tools and tool acceptability.

Only part of the interview data is used in this paper. However, responses to all questions were scrutinised because demand-related issues could emerge relative to any question.

2.4 Analysis

The core task of the drywall installation was defined after having familiarised with the work through the interviews. The aim was to perform such a definition, which is appropriate and relevant also from the perspective of the workers themselves.

We performed a qualitative, thematic analysis (e.g., [3]) about work demands as expressed by the interviewees. The unit of analysis is a comment, that is, an expression of a single entity (related to one work demand), consisting of one or several sentences, all included in the same response. If the same interviewee mentions the same type of comment in different responses, those comments are treated as individual comments. It is also possible to have one sentence contributing to several entities (demands).

All comments are treated as equally important. The reason for several comments about some issue may be due to the number of predefined questions about it or because the issue was found so important by the interviewee. Matters that were not directly asked often triggered less comments which does not mean that the issue would be less important. For instance, there can be one comment about a specific subject, which is important based on its criticality in construction work or because it is said that the matter in question appears frequently. Accordingly, there can be several comments about a single matter only because that matter was directly asked about in the interview. Furthermore, most items were mentioned only related to one subcategory (demand) but in some instances, the same issue was noted in several subcategories, reflecting the nature of the issue.

First, work related demands were identified in interview data and, thereafter, classified into three predefined categories, the ones of dynamics, complexity, and uncertainty [11].

Quotations are included to illustrate the quality of the answers the workers have provided in the interviews. The most expressive expressions are chosen, which means that the verbally most talented workers are overrepresented in the quotations.

3 RESULTS

3.1 Core task of the drywall installer

Core task for the drywall installer is to build a drywall with good quality, within the time allocated to work. The drywall installer is the only role responsible for installing the boards of the drywalls, even if there are many colleagues from other fields to take into account in the work.

The good quality of drywalls is vital for the success of the indoor construction. The location of drywalls defines the main structure of the room, enabling the appropriate installation of the cupboards and the doors. Poor quality of the wall can be clearly visible, so notches and other variations are to be avoided. The location of drywalls dictates, e.g., whether a door can be opened or whether a cupboard fits in the dedicated space. In the interviews, the demand for good quality was often mentioned, even to the point that it was considered a highly personal objective, extending beyond the boundaries of own task: "*I need to think, for example, that if doors and door frames will be installed, they shall fit in and be functional, I must think over that thing too and everything that will be installed there; I must ponder that they can be installed, I cannot just install the walls and say that well now that's it*" (Worker 4).

The work at the construction site has objectives also related to time. To build all components in a building, workers need to do their work efficiently and fluently in collaboration with other workers, within the temporal limitations of their work.

3.2 Core-task demands

3.2.1 Dynamics related demands. There were 64 comments related to dynamic features of work. Dynamics-related comments fall into two main categories: the one related to constant hurry and another related to unexpected issues.

Hurry was frequently mentioned in interviews, usually related to pressing timetables, even if there was no interview question related to hurry. The work can be delayed already when the worker arrives at the site for the first, agreed-on time: "*When you go to the construction site for the first time, they say that you are two weeks late, it is so common, there is much too much hurry. It applies to all of us*" (Worker 1).

Strict timetables can have several unwanted consequences, such as the quality of work can sustain: "*Timetables are so strict that we have to work parallelly [even if that is not the objective] and then it may become almost impossible to wait enough for [substance] drying*" (Worker 3). Hurry can even result in demolishing the built item: "*We install the wall in a hurry. And then we measure the square meters to get the money and then we demolish it so that others can [do their work]. This happens all the time and quite a lot*" (Worker 1).

In some cases, hurry is due to competition at the site, due to undefined working order: "*There is [competition] as working order is sometimes agreed on and sometimes not*" (Worker 2).

Another source for dynamics is unexpected issues at the site. Drawings and plans can be changed during working, tools may need fixing, causing delay in work, and there can also be unexpected physical issues. The example provided in the interview about the physical issues was about rain – it can pour on the floor, preventing to perform the planned work.

Work can also be suspended, because some important professional is absent, there are no plans or material available, or the site is so messy that is needs to be cleaned first. Sometimes strict timetable also causes delays in working: "*The other reason [for delays in working] is that timetable is so pressing that we must wait that somebody else has done his work before we can start to work*" (Worker 1).

3.2.2 Complexity related demands. There were 98 comments related to complexity of the work, fitting under a variety of categories. In drywall installation, sometimes the usual order of working is not possible. Normally, the drywalls are built first, and only after that, the technology is installed.

Working in the wrong order makes it difficult to install the drywalls since "*there is not necessarily enough space to build the drywall if [the technology] is on your way*" (Worker 2). Similarly, there is no space for working if the construction site is messy. Sometimes drywall installers must make room and clean up before the work itself can start, even if drywall installers are not accountable for other people's messes. Clutter makes it impossible to work properly with large wallboards.

Meticulousness is needed in drywall installation, adding complexity. Meticulousness is emphasised on the one hand in crucial work phases where mistakes can easily occur, and on the other hand as drawings are accurate in a challenging way. The accuracy of the drawings is related to the inflexibility of the measurements: "*The architects draw them so that they are exactly from line to line, not a single extra centimetre departing, and then if an element happens to be slightly tilted, even if two centimetres out of place, it can topple the whole thing*" (Worker 4). Additionally, the work itself involves complex tasks: Sometimes the drywall installer has to build more complicated openings (especially if the building technology has already been installed), make difficult measurements, or consider several different variables that affect the work, such as different wall types or floors at different levels.

The drywall installer needs to proactively consider the later phases of the work. Work must be considered as a whole: "*Drywall installer must understand what the location will look like [when ready] and based on that he [for example] strengthens the wall [when needed], this information is not in any construction drawing*" (Worker 8). Building a drywall requires cooperation between different installers. Correspondingly, the work of others needs to be considered, and that brings its own challenges to the work, especially if cooperation is not fluent. Mistakes by other installers and being late relative to the schedule can affect the drywall installer's work. After all, the drywall installer takes more responsibility for the whole: "*They [air conditioning installers] don't think about what the result looks like, they often think that they just put it there and that's it, that they [drywall installers] will check it*" (Worker 4).

Collaboration without common language among workers adds complexity. There can be foreign workers in the capital area who do not know English or the local language. Sometimes it remains unclear whether instructions have been understood, and the work is complicated by long communication chains through supervisors of the foreign workers, not usually present at the site, who speak the language in question.

The plans and drawings can be poor. The plans and construction drawings are either incomplete or it is not possible to follow them: "*Sometimes there are such structures in the drawings that you cannot build, it's against natural laws, for instance you cannot build the other side of the wall because there is a concrete wall*" (Worker 10). Different plans, such as paper-based construction drawings and 3D models, may also conflict with each other. It was perceived that the quality of the plans had decreased, which appeared in the drywall installer's work as a requirement for continuous adaptation. Drywall installers have to constantly plan and think about compensatory solutions during the work and make independent decisions - in these cases, experience was seen to compensate for incomplete plans.

There are sometimes problems with materials as well in drywall installation. There may be too little or too much material, it may be of poor quality, there may be challenges in delivery, or the material may be of the wrong type.

The lack of experience of the superiors also places demand on the drywall installers. According to the interviewees, management today has less experience, which must be compensated by the employees' own professional skills: "*After all, there are quite a few of them who know the end result and what it should be, there can be quite a few trainees, so someone has to know and if it happens to be the drywall installer, he/she tells everyone else*" (Worker 4). The inadequacy of superiors was also found to be related to the lack of the face-to-face discussions: "*Exactly, [superiors do not visit at the site but only make mobile phone calls], and there is less and less superiors with strong experience*" (Worker 3). And finally, construction work is not safe, adding complexity in the work of drywall installers since the worker needs to consider safety aspects in a daily work: "*Everybody at the site must know what happens there, it is a dangerous environment*" (Worker 5).

3.2.3 Uncertainty related demands. There were 31 comments related to uncertainty, falling on several categories. Firstly, plans and drawings lack information: *"We don't know exactly where the sink will be, so we must install the related supporting panel to a larger area so that it is sure it will support the sink"* (Worker 1). Missing plan and drawing-related information sets such demands to the installer that are originally dedicated to other roles: *"[There are] deficient drawings. Planning is unfinished, I myself must finish the planning"* (Worker 7). This situation seems to be rather frequent: *"Usually there is always missing something [in construction drawings]"* (Worker 6).

Drawings can also be obsolete so that the worker is not aware of it; this may lead to installing the wall twice: "*Architects make changes [in drawings], but if they are not updated to our drawings, somebody else makes the corrections*" (Worker 10). Workmate may inform drywall installer about a new drawing: "*Well for example [I learn that the drawing is obsolete when] a plumber walks there, says that why are you doing this here, this is not the location*" (Worker 1).

Measures can be missing, and that is not even rare: "*Really, I haven't seen for 20 years such a floor plan that has all measures*" (Worker 4). The location of work tools and the one of work material is not always known, and workers need to take time for searching them: "*Yes, there are plenty of those [problems in logistics], you need to search for the material*" (Worker 8). One possibility in this situation is to ask the superior for help: "*And we call to the superior, if the trash can is missing or we don't have screws or screwing tips or [other tools]*" (Worker 11). This may happen more frequently in big organisations: "*In big companies with a lot of workers, they often need to search for the tool*" (Worker 6).

It is not always known whether the collaborative team is available: "*It is always possible that it is unclear, it depends on the other team whether they have the capacity to do their task according to mutual agreement*". The work with hourly wages can be related to unawareness of the next task: "*If the superior does not command*

them, many workers just wonder what to do next. They have plans, of course, but as they work with hourly wages, they don't constantly ask what to do next" (Worker 3).

Finally, information of the current situation at the site can be missing: "*In principle, all dangerous locations shall be marked and there should exist no holes without a marking. Sometimes a marking is missing. But for a while ago there was a vehicle [blocking the route for cars at the site] and it meant that another vehicle could not pass it, these kinds of situations can emerge*" (Worker 8).

4 DISCUSSION

Our first and main research question was about the content of the work demands of the drywall installers. We interviewed 11 drywall installers. The comments related to work demands were identified and classified into the categories of dynamics related demands (64 comments), demands related to complexity (98 comments), and demands pertaining to uncertainty (31 comments). Further classification was performed within these three main categories (demands), resulting in 28 subcategories with the total of 193 comments. Issues related to many kinds of demands were the ones about the floorplans and construction drawings. These demands were related to hurry and changes in work, they could make the work more complex, and they also raised uncertainty in working.

Our results are in accordance with the existing literature. In subcontractor interviews, Loosemore [10] identified poor relationship between the young supervisors and the workers. Furthermore, the subcontractors complained that superiors tend to use computers for interaction whereas in our study, mobile phone was perceived to be used instead of in-person discussions [10]. In our interviews, young superiors were not trusted because they lacked experience and their communication style (avoiding in-person contacts) was found insufficient. Poor coordination and planning, mentioned in the study of Loosemore [10], is reflected in our results in the demands related to the problems with plans, material, and personnel. Weaknesses in documentation and clashes in design documents, mentioned by Loosemore [10] and Seppänen and Görsch [16] correspondingly, was a repeating theme in our interviews.

Our study confirms the results of Seppänen and Görsch [16]. Weakness in communication, resulting in the lack of understanding the project as reported by Seppänen and Görsch, was mentioned in our interviews by a drywall installer who noted that in big companies in which personnel works with hourly wages, a lot of time is spent in searching for a tool and in wondering, what to do next (demand category Uncertainty). Unrealistic timetable for construction projects was identified as a source of waste in the study of Seppänen and Görsch [16] and a dynamics-related demand to workers in our study, resulting in many problems in the construction project. The need to search for material, which is sometimes also missing, was mentioned as one source for wasted time in the study of Seppänen and Görsch [16]; missing material was a demand related to uncertainty in work in our study. Finally, the need to do preparatory measures before actual work was identified in the studies of both Seppänen and Görsch [16] and the one of ours. In our study, the messy workplace was related to interruptions in work (dynamics related demand) and to the struggle for space, vital for the ability to focus on work task (complexity related demand).

To shed light on the different parties involved in the demands, we reclassified the demands according to the primary party responsible for managing the workers' demand (Table 1). The usage of the term "primary" is an informed decision: reason for the demand may be beyond the grasp of the primary responsible party. If the demand is to be solved at the site, the primary responsible party to manage the demand is the worker, the superior, or both. In some cases, the construction project planner, who is responsible for the planning, including also timetable, floor plans and construction drawings, is the primary responsible party. Furthermore, all demands are not necessarily to be primarily managed by a single party: both the workers and the superiors at the site are considered responsible for the safety at the site.

All in all, Table 1 presents all demands the workers face and often also solves at work, but in many cases the worker is not the party, which is primarily responsible for managing the demand. This makes the demands more challenging as it can be difficult or impossible for the workers to perform all required activities for such demands, which are primarily to be managed by others. This is, for instance, the case when plans are missing: the worker can only ask the superior for help.

The reason for the success in the construction work seems to be the work experience of the drywall installers, resulting in expertise in various work-related tasks. This experience not only supports in managing the work tasks that the drywall installer is expected to manage, such as complex tasks. The experience also compensates for the lacking experience of the superiors, a task far beyond the scope of the tasks of the drywall installer. Furthermore, the experienced worker is able to compensate part of the deficiencies in the floorplans and construction drawings. It requires developed expertise in understanding the whole structure around the wall and understanding how the contribution of other workers shall be taken into account during all installation phases.

The studies reflecting the problems in the construction industry in a larger scale are closest to the demands, which are primarily managed by the construction project planners in our study (Table 1). Poor productivity development (e.g., [6, 14]) and, especially, the clash of the needs of different roles and insufficient information exchange in the construction project is probably connected with the pressing, unrealistic timetable according to which the worker tries to work.

It is hard to find the reason for poor floor plans and construction drawings, the other group of demands identified as being primarily managed by the construction project planners. The work of an architect may be so hectic, for instance, that there is no time to apply oneself to these artifacts in the needed level of detail.

The construction project planner is probably not the only responsible party for these demands or issues. The surrounding society sets its requirements on the construction industry, affecting the work of the construction project planner. The planner represents the party, which mediates the requirements of the society to the construction project, having additionally its own needs and demands.

Inadequate safety has been identified as a global problem in the construction industry [2]. The demand of safety has also been identified among our interviewees. Safety related problems did not appear severe as expressed in the interviews – interviewees appeared to be aware that the construction site is dangerous, but it

Table 1: Work demands classified according to the primary party responsible for the demand; (d) after a demand denotes dynamics, (c) complexity, and (u) uncertainty related demand

Primary party responsible for managing the worker's demand	Worker	Superior at the site	Construction project planner
	Planned work is delayed due to, e.g., rain pouring to floors (d) Meticulousness is needed in task performance (c) Complex tasks (c) Later phases of work need to be considered proactively (c) The work of others needs to be considered (c) Site status not appropriate: Site is messy (d), No space for working (c) Collaboration challenge without common language among workers (c) Construction work is not safe (c)	Hurry due to competition at site, due to undefined working order (d) Problems with tools: Tools need fixing (d), Location of work tools not known (u) Problems with material: There is no material (d), Problems with materials (c), Location of material not known (u) One professional (group) is absent (d) Construction work is not safe (c) Usual order of working is not possible (c) Superiors do not have experience (so workers need to have) (c) Unawareness of next task (u) Unawareness of the availability of the collaborative team (u) Missing site related information (u)	Hurry: Timetable is pressing (d), Strict timetable causes delays in working (d) Issues with floor plans and construction drawings: Drawings and plans are unexpectedly changed (d), There are no plans (d), Poor plans and drawings (c), Obsolete drawings (u), Missing information in plans and drawings (u)

did not elicit worry or many comments. The reason can be in the experiences of these interviewees; they may have worked at the sites with only a small number of severe accidents. Alternatively, the zero-accident strategy, assuming that all accidents are preventable [20], really has taken root in the Finnish construction industry [15].

Pertaining to research questions, we also wanted to contemplate what demands can be managed with visual information. There are several possible ways to support the meeting of the demands. Task-related, up-to-date visual information is one of them. The benefit of visual information is that the information is available for everybody at the site, irrespective of the lack of the common language at the site. The usage of digital technology provides a light-weighted means to utilize visual information.

There are various possibilities to support the workers with visual information. Using the categorization in Table 1, pertaining to (i) the demands in which the worker is the primary responsible party, the worker has the demand to consider the drywall installation proactively. This means that the drywall installer needs to know how the space should look like when ready. Thus, an illustration of the finished space is needed. With a three-dimensional model of the finished space, to be shown, for example, in a mobile phone or through glasses with augmented reality, the installation would become easier.

Several professionals work in turn for the drywall, so the drywall installer would benefit from a tool for flexible work sharing. Some software integrated to a smartwatch or a mobile phone could be used for informing the selected worker that the wall is ready for his/her share of the work.

Regarding the demands, which are connected to (ii) the superior at the site, the finding of the lost tools and material is the challenge, which could be mitigated with visual information. To develop a navigator for a lost tool or material, two types of functionalities are needed; one for identifying the location of the tool and the material, for instance, with a moving robot able to perceive and identify the relevant objects, and another for showing the worker where to go to find the needed tool or material, that is, the navigator to find the way at the construction site.

To mitigate the demands originating from the work of (iii) the construction site planner, an updated document deliverer would be needed to prevent the workers from using obsolete construction drawings. If there were a device, such as a smartwatch or mobile phone, with a software that notifies when a new version is available, the newest version would be more probably used. The system could inform the workers that the newest version is not uploaded, and the message would disappear only after the uploading.

Finally, there are many roles with different interests working with the drywall. That is why it would be useful to have

a shared drawing to be used among the workers. Electrician and plumber, for instance, could mark the location of the holes they need on the board for their work. Then, the drywall installer could hole the board as needed. A digital drawing, easy to share and to draw in, would support the efficient usage of the construction drawing.

5 CONCLUSIONS

Our study confirms the results of other studies among construction workers and extends them. A lot could be done to support the work at the construction site by only focusing on the demands identified in this paper.

Having demands at work does not automatically mean that there are problems at work. According to the further classification of the demands, the primary party responsible for the demand can be the worker, the superior at the site, or the construction project planner. It is expected that within a work system, the performance of one party affects the work of another. The demands, which are primarily under the responsibility of the worker, appear appropriate (for instance, the demand of being meticulous at work, or to face also complex tasks).

However, there are also such demands, which appear to be inappropriate. From the perspective of the diversity of demands raised by a single issue, inappropriate construction drawings and floor plans (i) were the source for unexpected changes at work as the drawings could be updated during working, so that the worker must reorient him/herself to the work and possibly also demolish the wall that was already built (dynamics related demand), (ii) made the work complex as drywall installers had to compensate for the deficiency and errors in the drawings (complexity related demand), and (iii) drawings can be updated without a notice so that the drywall installer builds the wall according to an obsolete drawing (uncertainty related demand). Also, the pressure in timetable may result in even absurd consequences, as the workers are supposed to do their work within the timetable and then possibly demolish the built object. The experienced worker is truly and much needed.

There are many possible ways to mitigate the demands. Affecting the party, which is primarily responsible for managing the demand, is one option. Thus, superiors are responsible for taking care that there is enough material at the construction site, and it becomes a demand for the workers only if the superiors have not taken care of this. However, the primarily responsible party is not necessarily the reason behind the demand. For instance, workers are responsible for taking care of the floors wetted by rain, but workers cannot affect the rain. The reasons for the demands can be hard to find or influence.

The managing of the demands related to information needs can be supported by providing useful information. Visual information is especially needed when the workers at the site do not share a common language. The limitation in visual information is that not everything can be expressed only visually. Furthermore, if the information is to be delivered personally to each worker, a specific, personal tool is required. The work at the construction site is physically demanding and the tool should endure the hard circumstances.

Active intervention in at least the absurd or too harsh demands is relevant from the perspectives of the workers and the construction industry. Construction site is the location in which the plans are realised. Accordingly, problems in plans and in the way the work is managed are revealed in the practical work at the site.

Our results only provide a starting point for a closer look at the demands at the construction site, faced by the workers. The results are limited to the work of the drywall installers. Most of the interviewees had the educational background in a vocational school in the building trade. This may have affected the results or, alternatively, affected the fluency with which the workers expressed their opinions in the interviews.

Furthermore, the demands at the construction site would probably appear different from this study if the experiences of another party, i.e., the superiors, were interviewed. To get a full picture of the demands and challenges at the construction site, studying the work beyond the perspective of the worker is needed.

As this study is qualitative, caution must be made in generalising the results. For instance, education may not be a usual feature among construction workers globally, even if it may be more common in Finland, the country in which this study was performed. Finland may also have other unique features pertaining to the construction work, at least from the global perspective.

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