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A CASE STUDY ON GAMIFIED INTERVENTIONS FOR TEAM COHESION IN FACTORY WORK

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Abstract: *In this article, we aim to provide insights into the design and implementation of game elements for teamwork on the work floor and to study their effect. Inventing games to break monotonous jobs is a long-standing practice, yet conscious implementation of motivational elements of games at work is a recent phenomenon. Generally, gamification is used to enhance individual performance; it may be effective in enhancing teamwork as well. We developed game elements aimed at team cohesion and examined the effect of two gamified interventions (team performance feedback and personal profiles) on team cohesion in a factory. Results suggest that the interventions mainly raised attention toward the aspects of the work that were explicitly addressed. Team performance feedback led to increased task commitment and perceived team performance, while personal profiles increased nonwork-related conversations among team members. We conclude with lessons learned regarding the development and study of gamified interventions for teams on the work floor.*

Keywords: *gamification, team cohesion, applied design research, factory operators.*

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INTRODUCTION

Gaming at work is not new. Factory workers in the 1950s (Roy, 1959) and ’70s (Burawoy, 1979) were observed relieving stress and breaking the monotony of their jobs by inventing game-like motivations for their work. This increased the workers’ satisfaction as well as their productivity. Roy (1959) described “a game of work” (p. 160) that made the operation of an industrial punching machine more satisfying, with rules such as “As soon as I finish a thousand green ones, I’ll click some brown ones” (p. 161). Moreover, he suggested that informal noninstrumental interaction (e.g., small talk) is a key source of job satisfaction for monotonous operating jobs. Years later, Burawoy (1979) observed the same machine production factory. He described similar game-like strategies by workers to keep their jobs interesting, including game-like motivations for reaching production quotas. This motivation led to a high work pace and sometimes to operators clashing with management to defend the conditions for their productivity.

Factory jobs often lack the characteristics known to increase employees’ performance, motivation, and satisfaction, as described by the job characteristics model (Hackman & Oldham, 1980): skill variety, task identity, task significance, autonomy, and job feedback. Nonetheless the operators in the above-described factory exhibited self-implemented game-like engagement with their jobs. The workers transported themselves from a monotonous and tedious work experience toward a more fulfilling game experience, which can be defined as “the voluntary attempt to overcome unnecessary obstacles” (Suits, 1978, p. 54). Roy’s (1959) game of work and informal, noninstrumental conversations with colleagues are good examples of this.

Transporting a user experience from a nongame experience to a more game-like (or gameful) experience is referred to as gamification (Green, Brock, & Kaufman, 2004; Huotari & Hamari, 2012; Visch, Vegt, Anderiesen, & van der Kooij, 2013). Instead of leaving gamification solely to the workers, the current trend in business is to explicitly apply game elements (Deterding, Dixon, Khaled, & Nacke, 2011). Currently, most applications of gamification rely on game-like incentive mechanisms with points, badges, and leaderboards (Hamari, Koivisto, & Sarsa, 2014). However, when taking game design as an inspiration for nongame contexts, we find many more opportunities for making factory work feel like a game. According to McGonigal (2011, p. 346), games are the single best research laboratory for discovering new ways to reliably and efficiently engineer optimal human experiences. For example, game-like metaphors or challenges that are developed by the game industry often are used to improve employees’ work experience (Berendsen, 2014; Hsieh, 2010). By introducing motivational elements found in games, workers may become more satisfied with—and motivated toward—their jobs (Mollick & Werbach, 2014), typically leading to better performance.

Game Elements for Team Cohesion

Although many games are individual and competitive, they often rely on collaboration and teamwork as well (Salen & Zimmerman, 2005). For example, many sports games contain competition between teams, and in massively multiplayer online games, players form teams to overcome challenges and defeat virtual opponents. The elements that motivate players to

invest much effort in achieving collective goals, such as defeating opponents or completing difficult challenges, might also be applicable for operating teams in a factory. Providing a game-like goal is one way to achieve this. Yet games contain many other elements that stimulate collaboration, such as roles, discussion forums, and the exchange of resources (Warmelink, et al. 2017). Hence, by analyzing the teamwork process and selecting the appropriate game elements, individual motivation for collective performance may increase.

Organizational psychology provides inspiration for the design of game elements for teamwork. The literature suggests many conditions for high team performance (Ilgen, Hollenbeck, Johnson, & Jundt, 2005). Among other things, interdependence and cohesion frequently are mentioned in relation to team performance (Beal, Burke, McLendon, & Cohen, 2003). Interdependence is a precondition for individuals working as a team (Brounstein, 2002). The extent to which team members feel interdependent correlates positively with the extent to which they collaborate (Frenkel & Sanders, 2007), which in turn positively affects team performance. Team cohesion reflects the extent to which team members feel part of the group. Literature on team cohesion suggests several factors that lead to stronger cohesion: commitment to goals and tasks of the team (i.e., task cohesion), interpersonal interaction, and individual attraction to the team (i.e., social cohesion; Kozlowski & Ilgen, 2006). Interdependence, task cohesion, and social cohesion provide a fruitful starting point for developing game elements for team cohesion.

Game Design Interventions at a Factory

This article presents a case study of designing, implementing, and evaluating game design interventions for team cohesion within production teams at a strip galvanizing plant (Wuppermann Steel Netherlands). At this factory, unprocessed coils of sheet steel come in and shiny, coated, and cut coils of sheet steel come out. The production process is largely automated and optimized. Throughout their shifts, operators mainly sit behind screens, monitoring and maintaining the production line. Consequently, keeping the operators engaged in their jobs has become the major concern of the management. Additionally, the feeling of working as a team is low because the operators are divided among various sections of the plant. In this context, enhancing interdependence and team cohesion through game elements may be helpful in increasing the operators' engagement with their jobs.

Three years ago, a process was initiated in one production department to increase workers' engagement with team performance. In collaboration with a serious game design company (&RANJ, the Netherlands), LED displays with production figures (e.g., tons of processed steel) were replaced by touch screens in the factory hall and canteen (see Figure 1). These screens displayed a dashboard with real-time game-like infographics about the operating team's key performance indicators (KPIs) and click-through pages with detailed information about the KPIs. As a result of the display, according to the managers, the KPIs became a more dominant topic of discussion among the operators of that department

In this paper, we describe two studies of the effect of new game design interventions for team cohesion in two separate production departments of the factory (galvanizing and cutting). In the galvanizing department, interactive personal profile pages for all workers within that department were added to the already-present screens. In the cutting department, the still-present LED display was replaced with a touch screen displaying gamified performance information in

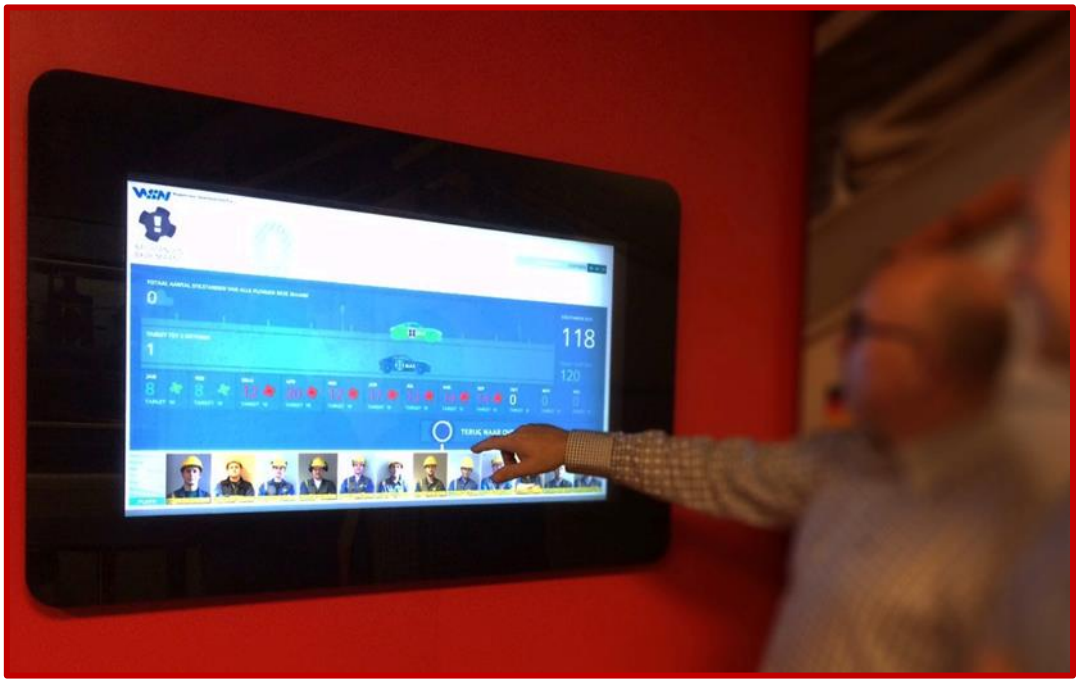

Figure 1. The touch screen in the canteen displays the performance (upper racing car) and target goal (bottom racing car) of the team at the galvanizing department, intending to engage team members regarding their shared output.

the factory hall. In addition to measuring the effect of game design interventions, we aimed to discover general guidelines for the design and implementation of game elements in nongame teamwork contexts. We therefore describe the theoretical as well as practical considerations within the design process. In the following section, we first introduce our perspective on gamification, then summarize organizational psychology literature about teamwork, concluding with the theoretical framework that served as the basis for the interventions. Next, the context of the factory and perspective of the operators is addressed. The theoretical framework and user/context factors were used to inform the design process as well as to form hypotheses regarding the intervention studies.

THEORETICAL BACKGROUND

Gamification

The rise of computer games has increased the interest in consciously implementing games as aspects of work processes at companies (Edery & Mollick, 2009; Reeves & Read, 2009). Gamification, the use of game elements in nongame contexts (Deterding et al., 2011), is increasingly applied and investigated in business environments (Reiners & Wood, 2015). Currently, gamification is operationalized primarily as game-like incentive mechanisms (Hamari et al., 2014). For example, participants could gain points for tagging photos (Mekler, Brühlmann, Opwis, & Tuch, 2013), badges could be earned for specific activities at a peer-to-peer trading service (Hamari, 2013), and sales achievements would be displayed as a basketball

game (Mollick & Rothbard, 2013). These implementations demonstrated marginal positive effects on productivity, effort, and job satisfaction that, to a large extent, depended on the compliance of the users.

However, as Bogost (2014) critically claimed, current gamifications seem to exploit mainly the motivational elements of games instead of inherently motivating employees for particular tasks. Rather than just adding game-like incentive mechanisms, we suggest to gamify a worker's experience of his/her job. Research on self-determination in games (e.g., Ryan, Rigby, & Przybylski, 2006) demonstrates that successful games derive their motivational power by tapping into basic psychological needs of the player. As a result, gamers shift more easily toward internalized and intrinsic motivational states, which are often related to increased commitment and performance in work contexts (Ryan & Deci, 2000).

This does not mean, however, that gamification should be aimed solely at intrinsic motivation (e.g., simply enjoying an activity). Instead, gamification should provide a variation of motivators, intrinsic as well as extrinsic (e.g., enjoying the outcome of an activity) because different player types can experience the same affordances differently (Huotari & Hamari, 2012). A good example of combining intrinsic and extrinsic elements is the coffee shop game that supports self-managing service desk teams at a banking company to organize their work (Berendsen, 2014). Their work activities were communicated through a coffee shop metaphor, thereby strengthening the employees' understanding of their activities. Beyond increasing their enjoyment in their work, the process also raised motivation for extrinsic elements, such as acquisition and sales. Another example is a multiple-choice quiz that encourages home workers of a service desk to get in touch with each other (Hsieh, 2010). In the quiz, participants were extrinsically motivated (i.e., wanting to win) toward getting to know colleagues better and, simultaneously, the activity of getting to know colleagues better in the online chat area was inherently satisfying.

The coffee shop game (Berendsen, 2014) was added as a gamification layer on top of the nongame teamwork situation, whereas the multiple-choice quiz (Hsieh, 2010) was integrated into the already available online communication functionalities for home workers and their profile information. These examples demonstrate that gamification can involve either adding a game layer on top of the real teamwork or adding some game elements and/or making existing nongame elements more game-like. When developing game design interventions for production teams, we took both strategies into account. Note that the coffee shop game and quiz about colleagues were aimed at teamwork, whereas most gamification literature is concerned with individual motivation for individual performance. Thus, to inform our design process of game elements for teamwork, organizational psychology literature was reviewed.

Conditions for High Team Performance

In organizational psychology, team performance has been investigated extensively. Much of the work emphasizes conditions for high team performance (see, e.g., Ilgen et al., 2005) because conditions (e.g., organizational impact, defined focus, knowledge, and skills) show more significant effects than process variables (e.g., conflict management and communication; McGrath, 1997). Team performance is defined through several dimensions: effectiveness, efficiency, learning and personal growth, and team member satisfaction (MacBryde &

Mendibil, 2003). Of course, the organizational goal of operating teams is to be effective and efficient; yet without learning and team member satisfaction, teamwork is hard to sustain.

Following these dimensions, Castka, Bamber, Sharp, and Belohoubek (2001) suggested a combination of system factors and human factors for developing high performance teams. One of the system factors is information about performance measures, which directly relates to the real-time performance feedback on the KPI screens in our study. Regarding the application of direct performance feedback, research is not well developed yet, although current technology systems have the potential to assess team member behavior and performance in real-time (Kozlowski, Grand, Baard, & Pearce, 2015). The available literature suggests that individual feedback raises a team member's attention and effort for individual performance and team feedback improves team performance (DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004). Additionally, teams tend to focus mainly on using measures that are used for providing rewards, ignoring other measures (Mendibil & MacBryde, 2006). Hence, for example, rewarding team productivity may lead to undesirable neglect of side-tasks, such as cleaning. Moreover, when employees are rewarded individually, implementing a team performance measurement system is found to be less effective for the same reason.

When projecting these insights onto our case, the galvanizing factory seems mainly organized to support the system factors. The production teams are at the heart of the production process: They have a clear goal, the distance with the management is small, and the KPI screens provide real-time information about the team performance. Yet the support of human factors could be improved, such as recognition for each operator's individual contribution (Zigon, 1997) and the knowledge and skills to work at every section of the production line. Hence, our study aimed to improve human factors.

Team Cohesion

To specify human factors in relation to team performance, we tapped into literature on team cohesion. Team cohesion is the most extensively investigated construct underlying team processes (Grossman, 2014; Kozlowski & Ilgen, 2006). More cohesive work groups displayed greater amounts of courtesy (Kidwell, Mossholder, & Bennett, 1997), efficiency (Beal et al., 2003), viability (Chang & Bordia, 2001; Mello & Delise, 2015), coworker assistance (Frenkel & Sanders, 2007), and satisfaction (Voulgari & Komis, 2015). Team cohesion generally shows stronger correlations with efficiency (e.g., completion time) than with effectiveness measures (e.g., task completion; Beal et al., 2003). This is explained by the fact that team cohesion includes task cohesion (i.e., commitment to the team's goals and tasks) and social cohesion (i.e., interpersonal interaction and personal attraction to the team; Kozlowski & Ilgen, 2006). Task cohesion increases team performance (Carless & De Paola, 2000; Chang & Bordia, 2001), yet social cohesion is more related to collaborative behavior (Beal et al., 2003) and the viability of a team (Chang & Bordia, 2001; Mello & Delise, 2015). However, social cohesion could in some situations deteriorate team performance due to the pressure to conform (Rovio, Eskola, Kozub, Duda, & Lintunen, 2009).

Techniques for enhancing team cohesion in favor of team performance are not well developed yet (Grossman, 2014; Kozlowski & Bell, 2013). Team performance itself was not found to directly influence team cohesion; instead, cohesion reinforces performance (Chang & Bordia, 2001). A recent study on team cohesion in massively multiplayer online games

(Voulgari & Komis, 2015) suggested social and achievement-related forces. Among other things, social forces entail a player identifying with the interests of group members and social interactions. Examples of achievement-related forces are successful cooperation, relevancy of group goals to individual goals, and linking individual success to group success. This relates to workflow interdependence, which is an important moderator for the cohesion–performance relationship (Beal et al., 2003; Gully, Devine, & Whitney, 2012). Workers help each other more when tasks are more interdependent (Frenkel & Sanders, 2007), and when they help each other more, they have a stronger desire to continue working together if the team performs well (Spataro, Pettit, Sauer, & Lount, 2014).

In conclusion, strengthening task cohesion (i.e., targeting behaviors that enhance commitment to the group task) seems the most important factor for improving teamwork (Carless & De Paola, 2000). Yet stimulating social cohesion (i.e., attraction to the group and interpersonal interaction) and emphasizing interdependence may improve team performance in the long-term (see Figure 2).

Research Framework

As explained in the Introduction, the operating team's performance had become a key factor for the factory's output because the automated production process had been largely perfected. Team cohesion and interdependence are key factors for achieving high team performance, according to the literature. Hence, we developed game elements that were meant to influence the factors that enhance team cohesion and interdependence. Figure 3 shows how the game elements on the interactive screens were based on the theoretical model presented in Figure 2. Introducing real-time feedback via the KPIs was expected to increase task cohesion within the production teams. To increase social cohesion, game elements were aimed at stimulating interpersonal interaction. More specifically, personal information (e.g., birthdays, hobbies, and interests) was expected to stimulate informal conversations. By showing one's contribution to the team, we anticipated an increase in perceived interdependence. One's personal information and contribution to the team would be displayed in one's own profile page.

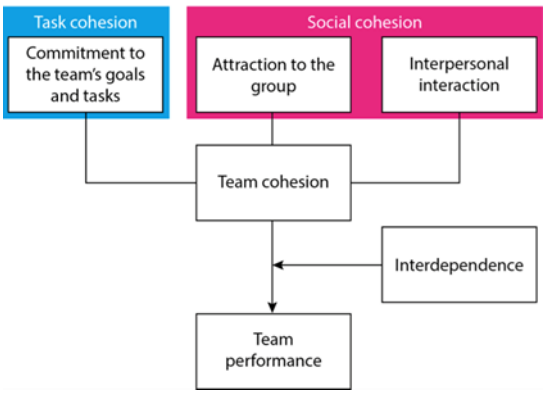

Figure 2. The theoretical model: Team cohesion and interdependence positively affect team performance, and team cohesion consists of task- and social cohesion.

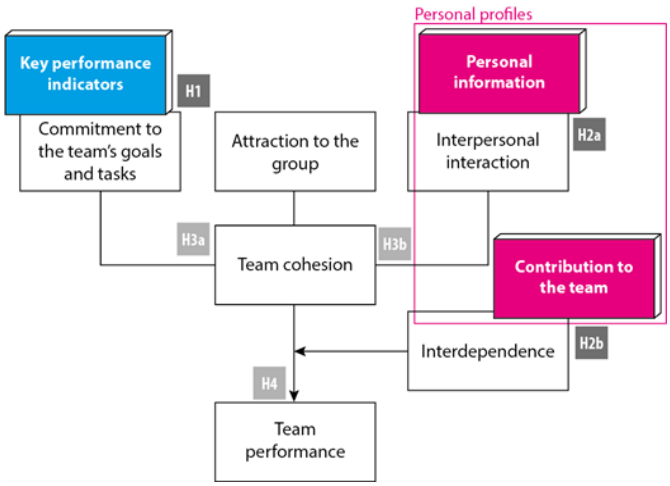

Figure 3. Our research framework: Game elements (colored boxes) were introduced that addressed aspects of task cohesion, social cohesion, and interdependence. We primarily expected to find a direct effect (H1, H2a, and H2b).

As a first step in investigating game elements for team cohesion, the present study was aimed at measuring the direct effect of introducing game elements. That is, the effect of real-time KPI feedback on commitment to the team's goals and tasks (H1 in Figure 3), and the effect of personal profiles on interpersonal interaction (H2a) and interdependence (H2b). Of secondary interest was the effect on team cohesion (H3a & H3b) and performance (H4).

USER/CONTEXT ANALYSIS

The decision to translate KPIs, personal information, and contribution to the team into game elements on the screens was grounded not only in the literature, but also on a review of human factors and system factors at the galvanizing plant. System factors such as production line, task division, and KPIs served as inputs for the design of KPI graphics and the workers' contributions to the team in the personal profile pages. Through exploratory talks with operators from various sections of the production line, we gained insights into their experiences of human factors (e.g., job motivation, team cohesion and interdependence) prior to the intervention. Thus, the game elements for personal information and contribution to the team were selected on the basis of these talks.

System Factors: Production Line, Task Division, and KPIs

As Figure 4 shows, the production line of the galvanizing plant consists of two departments based in separate halls: galvanizing and cutting. In the galvanizing department, unprocessed coils of sheet steel are galvanized, flattened, and sometimes chemically processed. The processed steel is coiled up again and then moves to the cutting department where the processed coils are cut into prescribed sizes and then packaged for shipping. This process runs continuously, 24 hours a day and 6 days a week. In each department, a team of operators runs the line for 8 hours; thus there are 3 shifts a day.

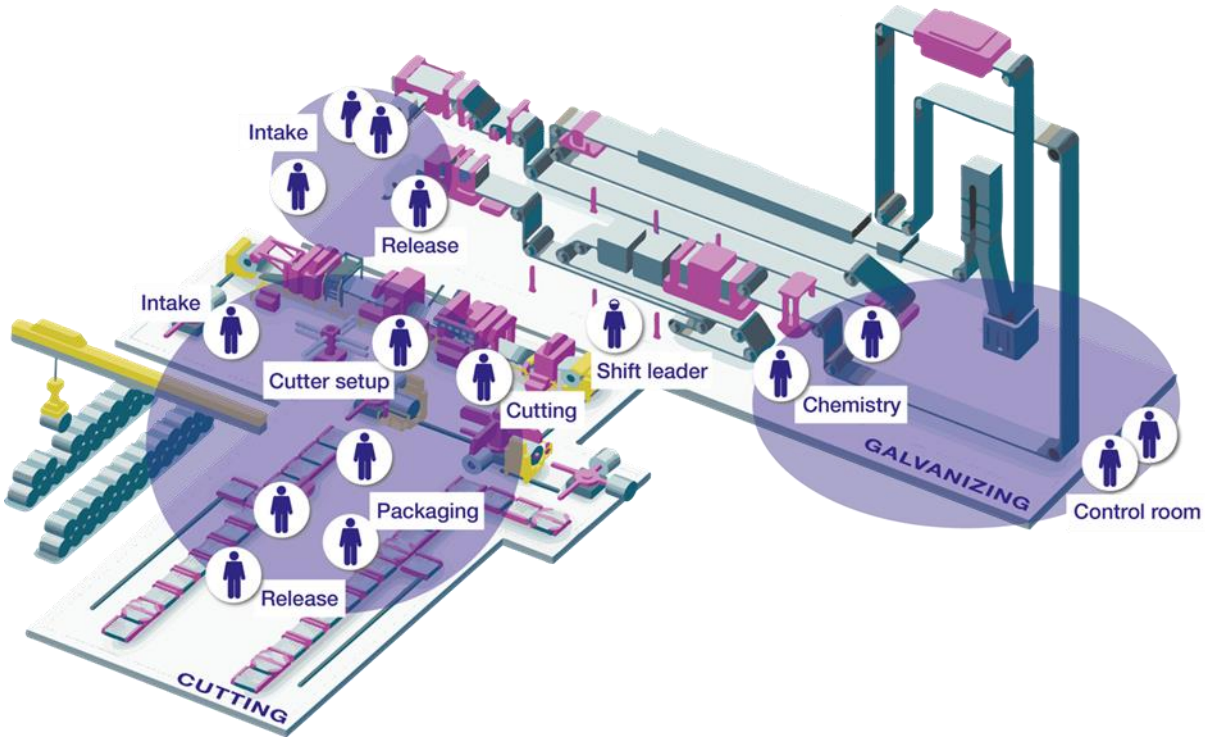

Figure 4. A map of the two production halls of the strip galvanizing plant, with the galvanizing department (top-right) and cutting department (bottom-left). Each department consists of sections (labeled) with a certain number of operators (human icons). Galvanizing operators experience separation within the team (two purple circles at the top), cutting operators do not feel this separation (bottom purple circle).

The galvanizing department is divided into four sections: intake, release, chemistry, and the control room. At the intake section, operators position the unprocessed coils and weld them to the ongoing production line. Galvanization takes place in a tower at the other side of the hall, next to the control room. Control room operators are responsible for the speed of the line and the galvanization process in the tower. Before and after galvanization, several chemical processes can take place. Chemistry operators are responsible for the proper set of chemicals. At the end of the line, release operators verify the quality of the galvanized steel and make sure that the processed coils are transported to the cutting department. Most operating positions are equipped with several monitors and a button panel.

The galvanizing teams are assessed on four KPIs: production, first-time right, standstills, and days without injuries. Production refers to the tonnage of steel that each team processes, and first-time right reflects an efficiency measure, referring to perfect processing without any loss of material and time. Reducing the number of standstills is a major concern of the operators. A standstill happens when the line stops or when the steel sheet rips. This not only leads to delay, but also a financial loss because all the steel currently in the line needs to be replaced after a standstill. For each KPI, the management provides targets that the teams need to meet. Depending on the shift leader, a team may prioritize KPIs differently. One team might be focused more on reaching maximal production, whereas another team is equally concerned with leaving a clean workplace to avoid injuries. Two touch screens display real-time infographics about the output. (Figure 5 & Figure 6 show two example pages that were already

on the screens before our intervention.) One screen is placed in the canteen and one in the hall near the intake section.

The cutting department is divided into five sections: intake, cutter setup, cutting, packaging, and release. At the intake section, the galvanized coils are accepted from the galvanized line and stored. This section is largely automated and thus not always manned. The operator at the cutter setup is responsible for the knives that cut the coils, while another operator oversees the cutting. Packaging and release operators assure that the coils are readied for shipping and are shipped. The operators in the cutting department are not dominated by a continuously running production line, yet they do have production targets. Next to reaching production targets, they are concerned with client satisfaction. Coils need to be cut neatly, without deforming the coil or fraying the edges. Clients are asked to give feedback on the quality at delivery. The feedback results are all available in the factory's data system that could be shown through graphics on the screen.

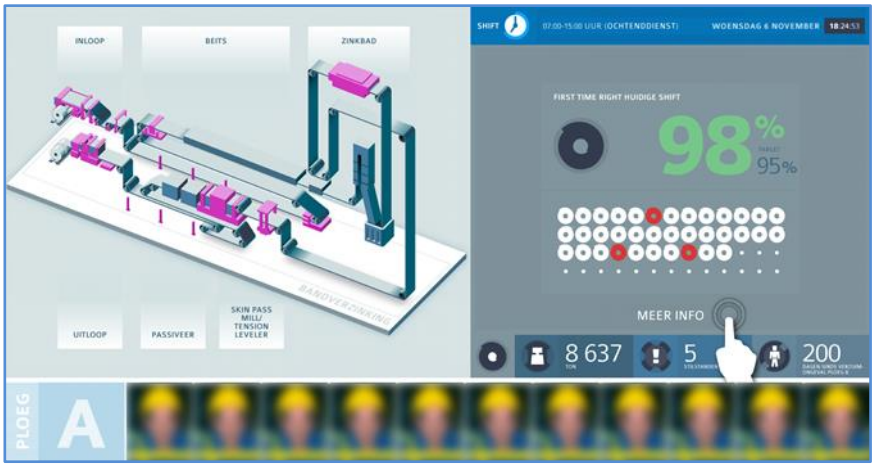

Figure 5. Overview page of the screen at the galvanizing department: production line (left), real-time key production indicators (KPIs, right), and photos of the team currently on duty (bottom).

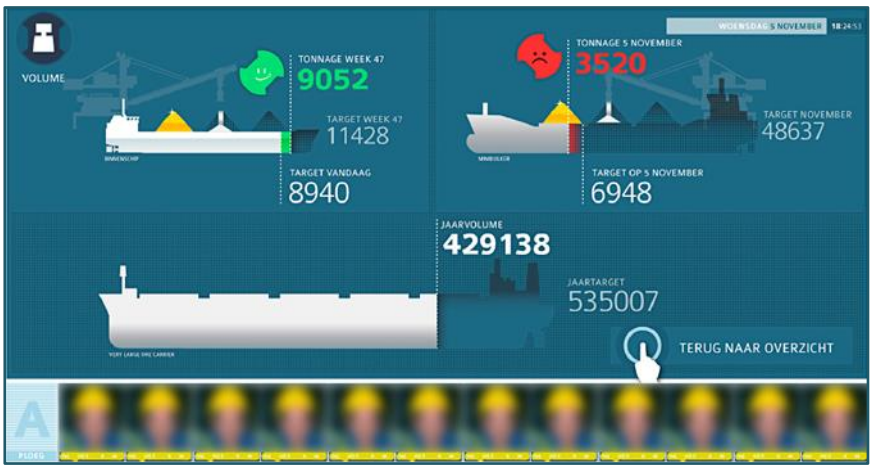

Figure 6. Detailed information about production targets on the screen of the galvanizing department. A full ship indicates that the target is met. In the top-left, tonnage of steel produced in a particular week, the ship on the top-right depicts the monthly production, and the bottom ship shows the yearly production.

Human Factors: Team Cohesion and Interdependence

In the exploratory talks with the coworkers, most galvanizing operators mentioned the physical separation within the team operating the galvanizing department. They stated that the team consists of "islands." In Figure 4, these islands are identified. Thus, the operators at intake and release are quite distant from the control room; the chemists work in the middle of the hall. The operators explained that the lack of physical proximity cuts the team in half. Moreover, even though intake and release operators work near each other, they do not often speak to their coworkers because the release operator needs to continuously concentrate on the line. The operators use handheld transceivers to communicate. Yet if everything runs properly, there is no communication so that the radio line is available for emergencies.

In addition to the physical separation and rare communication, differences in tasks and hierarchy separate the operators. For example, control room operators control the speed of the processing line, thereby being responsible for the production target, whereas intake operators need to insert and weld the coils properly to reach the first-time right target. When the line runs fast, intake operators need to work harder to keep up and make no mistakes. If they fall behind, they contact the control room to slow down the line. Consequently, control room operators admitted that they sometimes complain about the slow intake operators, while intake operators sometimes complain about the control room operators pushing them too much. Moreover, there are hierarchical differences between operators. New employees generally start at intake and work their way up toward becoming a control room operator. Ideally, all operators should be able to take over at every position; yet due to differences in education and experience, chemistry and control room operators hardly ever work at the intake or release sections.

Overall, the continuous production line dictates the galvanizing operators' work experience. In the exploratory chats, workers expressed their main motivation as keeping the line running; however, the physical separation, as mentioned regularly, can be expected to be obstacles to a feeling of interdependence and being part of a team. Thus, we researchers had to temper our expectations regarding increasing interdependence and team cohesion at the galvanizing department. Yet some operators expressed interest in more personal contact with colleagues. Hence, game elements for social cohesion could be a valuable intervention at the galvanizing department.

The cutting department would probably benefit most from game elements for task cohesion, as it contains fewer obstacles for social cohesion. The teams work in closer proximity and they replace each other on tasks more often. Hence, we expected that interdependence and social cohesion was already felt more strongly by the cutting operators. Consequently, introducing real-time feedback on KPIs, thereby raising task cohesion, was expected to have a stronger effect on overall team cohesion and performance than raising social cohesion through personal profiles.

STUDY DESIGN

Following the different situations in the two departments, we executed two separate intervention studies, with hypotheses regarding the potential outcome as described by Figure 3. Study 1 examined the effect of introducing a new screen with game-like KPI infographics on the commitment to team goals and team tasks (H1) in the cutting department. Simultaneously, Study

2 was executed in the galvanizing department, where the already present KPI screens were updated with improved graphics, including personal profile pages. Thus Study 2 examined the effect of additional gamified personal profiles on informal conversations (H2a) and interdependence (H2b).

Page Design

Figure 7 shows the pages and features on the screens for both studies. The development of pages for the new screen in Study 1 was a straightforward process. The company managers provided KPIs and game designers at &RANJ translated these into game-like infographics. The development of game elements for personal information and one's contribution to the team for Study 2 required a more elaborate approach. Based on the talks with operators, we selected the features that are presented below. Moreover, pop-up statements about colleagues (described below) were introduced to stimulate informal conversation. The following sections describe the pages and features in more detail.¨

Intervention 1: KPI Screen in the Cutting Department

The new screen for the cutting department consists of an overview page and three "more information" pages (see Figure 7). The overview page, shown in Figure 8, contains a static image of the production line on the left, real-time KPI data on the right, and photos of the team currently on duty at the bottom. The KPI information is presented in a carousel that automatically shifts

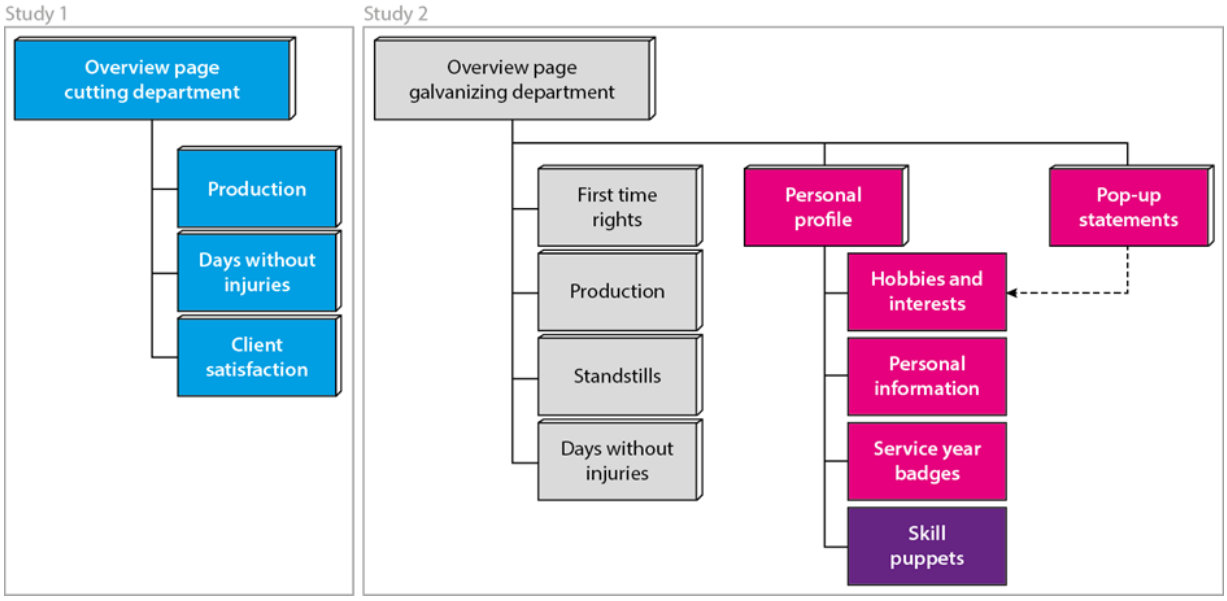

Figure 7. Content of the screens for both intervention studies. New pages (blue) were created to stimulate task cohesion in the cutting department. For workers in the galvanizing department, new pages and features (pink) were added to stimulate informal conversations and to increase interdependence (purple). The gray pages presented already existing information. Pop-up statements are statements about hobbies and interests of some of the operators that pop up on the screen at the end of each shift. The answers feed into the hobbies and interests of the particular operator's profile page. Skill operator figures show an operator's trained skills per section of the production line.

between KPIs. In Figure 8, the number of tons and coils shows the team's current production. When clicking on it, details regarding the daily, monthly, and yearly targets appear in the shape of ships that fill up with progress, similar to the graphics for the galvanizing department (see Figure 6). Days without injuries is represented by a number. The detail page shows the results of the past months and two racing cars represent the team's current performance and their target (similar to Figure 1). Regarding client satisfaction, the overview page displays the overall score through a meter (as in Figure 9) and the five clients that they produce the most steel for. The detail page lists the separate assessment criteria, including the number of complaints represented by an icon (Figure 9 on the left).

The screen was installed next to the entrance of the hall where operators regularly walk in and out. In this way, the cutting operators could have a regular look at the overview page.

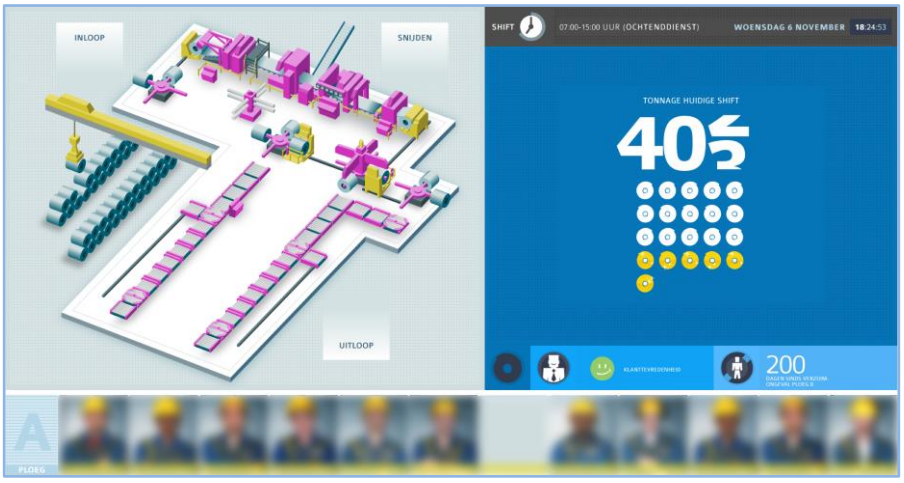

Figure 8. Overview page on the new screen at the cutting department: production line (left), The key production indicator (KPI) carousel (right) that rotates through information every 30 seconds, and the current team (bottom).

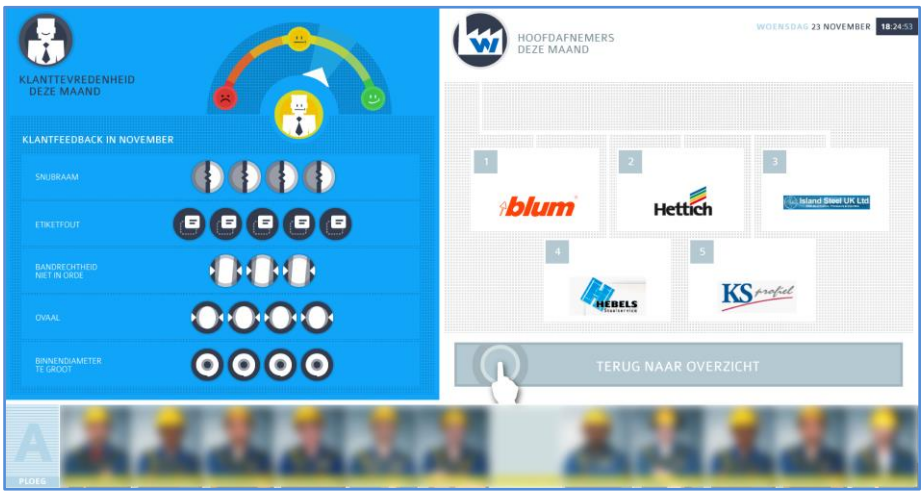

Figure 9. Client satisfaction page on the new key production indicators (KPIs) screen for the cutting department.

Intervention 2: Personal Profile Pages

Additional to the already existing overview page and four KPI pages at the galvanizing department, two new types of pages were added to the screens: personal profiles (Figure 10) and pop-up statements (Figure 11). For each operator, a personal profile page was created containing personal information and one's trained skills per section of the production line, accessible by clicking on the operator's image at the bottom of the screen. The profile pages contain date of birth, place of residence, hobbies and interests, service years, and role within the team. The service years are depicted as badges (shown upper-right in Figure 10). On the day that

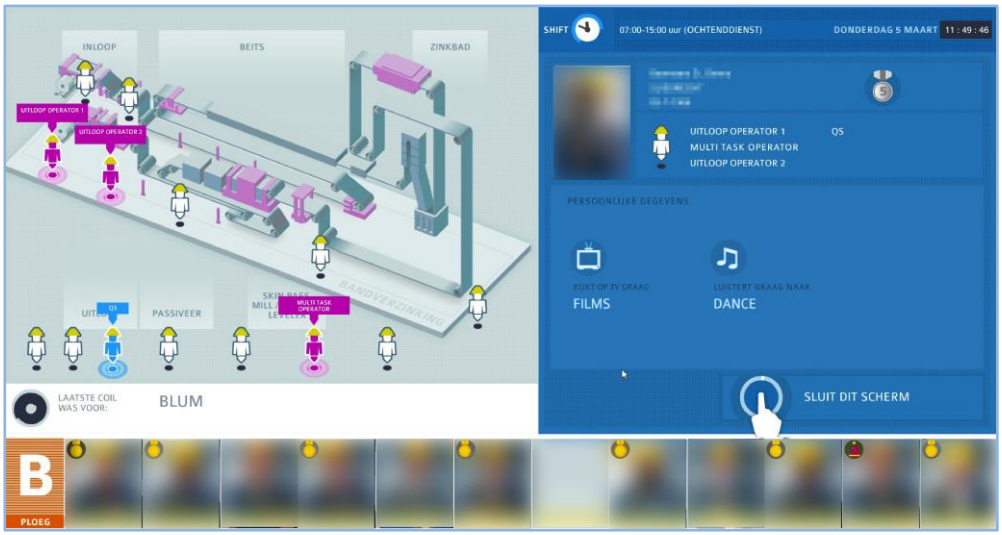

Figure 10. An example of a personal profile page that was added to the content of the screens in the galvanizing department: contribution to the team (left), personal information (right), badges added to the images of the current team (bottom).

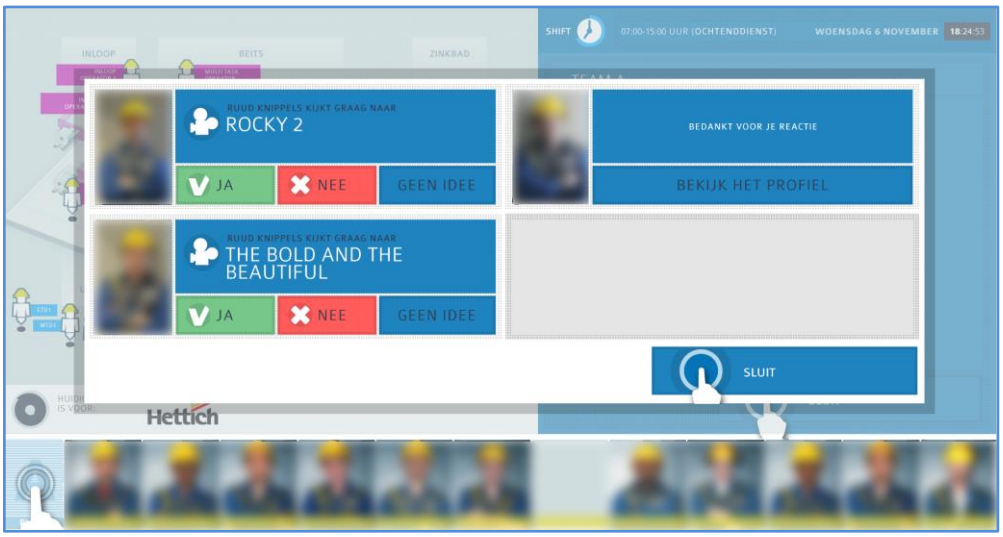

Figure 11. An example of the pop-up statements about interests and hobbies of colleagues available at the end of each shift, serving as input for the above-shown personal profiles.

an operator has an anniversary or birthday, a badge also appears on the operator's image at the bottom. The operator's ascribed roles within the team are described in text and visualized through the colored "operator figures" on the production line visual on the left.

The displayed hobbies and interests are not static pieces of information. Instead they show what colleagues have answered about the particular operator through pop-up statements. At the end of each shift, four statements about colleagues during that shift pop up, such as "Ruud likes to listen to jazz" or "Ruud likes cycling." These can be answered by pressing "yes," "no," or "don't know" (see Figure 11). The hobbies and interests data is gathered and displayed on the operator's profile page. Thus, rather than showing the correct hobbies and interests, the profile pages show what colleagues know (or think they know) about each other.

After implementation, several operators complained about the fact that their personal information (date of birth and hometown) was visible on the screen without being asked. They were allowed to opt for removal of this particular information.

METHODS

To measure the effect of (a) a new KPI screen on commitment to the team's goals and tasks and/or (b) additional personal profile pages on informal conversation and interdependence, all operators were asked to complete a questionnaire three times (see Figure 12 for the survey timeline; see the Appendix for the text of the questionnaire). The focus of the surveys was not only to measure the direct effects but also to assess how team cohesion and team performance were impacted. The questionnaires were the same for both studies in order to account for changes in the overall organization of the factory and the possible influence of one intervention on the other intervention (see Figure 13). For example, cutting operators could access the screens at the galvanizing department and vice versa. Hence, if we would find the same effects occurring in both departments at the same time this could indicate changes in the overall organization or the influence of the other intervention.

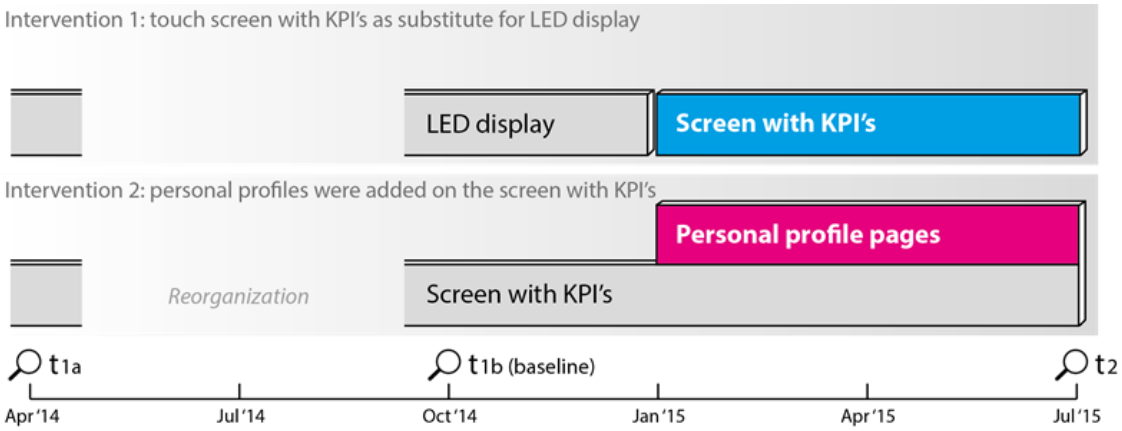

Figure 12. The scheme of the two intervention studies, with the intervention for task cohesion within cutting teams (blue) and the intervention for informal conversations and interdependence within galvanizing teams (red). The timeline for the studies and the study measurements (t) are shown along the bottom of the image.

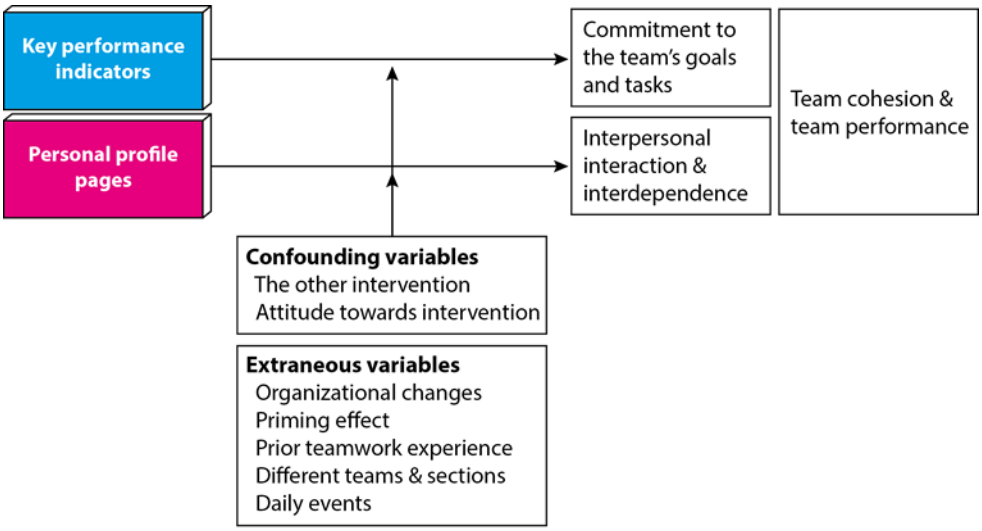

Figure 13. The interventions (boxes on the left) are assumed to directly enhance commitment and interpersonal interaction and perceived interdependence (direct arrows), thereby indirectly enhancing the operator's experiences of team cohesion and team performance, influenced by confounding and extraneous variables.

The first informant inquiry (t_{1a}) was implemented to check if the questionnaires themselves would affect the operators' teamwork experiences because the very experience of answering questions about teamwork could prime workers' awareness regarding teamwork (Murphy & Davidshofer, 2013). The data from t_{1a} also could signify the current state of the operators' teamwork experiences and indicate whether there were large differences between teams and sections, which could affect the influence of the screens on the operators' teamwork experience. To allow for the comparison of experiences of operators in different sections, the t_{1a} questionnaire inquired into the previous workday because, over a longer period, operators could be stationed at several sections. Moreover, the data could expose unanticipated extraneous variables. As shown in Figure 12, the first questionnaire-round (t_{1a}) was held in April 2014.

The second measurement period (t_{1b}) served as the study baseline measure. Unfortunately, a reorganization of the galvanizing department caused a delay in executing the baseline measurement for both studies, which eventually took place in October 2014. The questions were the same as in t_{1a}. However, instead of reflecting on the previous workday, the operators were asked to recall their experiences of the past weeks, to avoid any influence of particular day's events, such as a standstill.

Three months after t_{1b} (in January 2015), the new KPI screen (at the cutting department) and personal profile pages (at the galvanizing department) were installed. Six months after that (July 2015), the third questionnaire round (t_2) was executed to measure the effect of the interventions. To better interpret the data from the questionnaires, we wanted to know the operators' opinions regarding the new features. Thus, in addition to completing the questionnaires in t_2, 11 operators were interviewed to evaluate the interventions. We interviewed shift leaders and operators from the different sections in the galvanizing department because they were familiar with KPIs (from the prestudy usage) and the new personal profiles.

Participants

All participants were male operators. The variation in work experience was high (1 week–40 years) and all participants were full-time employees. According to Sanders and Nauta (2004), similarity in gender and percentage of full-time employees within a team has a positive effect on team cohesion. Thus we expected relatively strong cohesion to be present even before the intervention, that is, in the prime (t_{1a}) and baseline measure (t_{1b}).

Measurement

Completing the questionnaire (see the Appendix) took approximately 20 minutes. The shift leaders were instructed to distribute and collect the questionnaires and make sure that every operator was able to fill it in on a moment where it would not disrupt their work. The first page contained statements about team cohesion (i.e., islands and pride), task cohesion (i.e., task and goal commitment), social cohesion (i.e., nonwork-related talk), and team performance. These were mainly individual-level statements, e.g., "The goals of the team were important to me" or "I talked about nonwork related topics with my colleagues." We did not measure group-level team cohesion (Gully et al., 2012) because the game elements were aimed at enhancing the teamwork experience of the individual operators. Regarding team performance and informal conversations, the operators were asked to describe the performances and topics in a blank box. This allowed us to investigate whether their interests would change over the measurement times. The bulk of the questionnaire inquired about their experiences and behavioral interdependence with operators from each section. For each section they had to note to what extent they felt dependent on colleagues and to what extent colleagues depended on them. Similar questions were asked regarding helping and hindering, reflecting positive and negative behavioral interdependence (Deutsch, 2006).

The survey ended with questions about the importance of the screen, one's attention toward it, and some general information. For the operators in the cutting department, these questions referred to the screen at the galvanizing department at the first data collection point because they did not have a screen in their own department yet. Because the operators' shift leaders distributed the questionnaires, not much personal information on each respondent was asked. Yet to allow for within-subject comparisons, we did ask for service years at the factory and the total number of years they have worked. This information, in combination with knowing the team and section, made it possible to trace back to individuals. The questionnaire in the first round included an informed consent form that announced the two follow-up questionnaires. There was a strong drop in the response rate in the subsequent collection waves, which will be discussed in the following section.

Response Rate

Some of the questionnaires needed to be eliminated from the analysis because they were filled in with the same score at all statements, suggesting that the request to complete them was not taken seriously. The resulting numbers of responses per measurement time are presented in Tables 1 and 2, next to the number of employed operators.

Table 1. Number of Employed Operators and Respondents per Measurement Time in Study 1.

Cutting department		**t_{1a} (Apr '14)**		**t_{1b} (Oct '14)**		**t_2 (Jul '15)**	
		operators	respondents	operators	respondents	operators	respondents
Total		**35**	**31**	**35**	**23**	**35**	**24**
Per team	A	7	6	7	4	7	?
	B	7	7	7	6	7	?
	C	7	7	7	4	7	?
	D	7	5	7	5	7	?
	E	7	6	7	4	7	?
	Unknown						24
Per section	Intake	5	0	5	0	5	1
	Cutting	5	5	5	2	5	1
	Cutter setup	5	8	5	3	5	1
	Packaging	15	10	15	4	15	5
	Release	5	5	5	2	5	1
	Several		0		4		4
	All		3		2		3
	Unknown				6		8

Note. Number of employed operators per section is based on work documents.

Table 2. Number of Employed Operators and Respondents per Measurement Time in Study 2.

Galvanizing department		**t_{1a} (Apr '14)**		**t_{1b} (Oct '14)**		**t_2 (Jul '15)**	
		operators	respondents	operators	respondents	operators	respondents
Total		**45**	**39**	**44**	**27**	**44**	**12**
Per team	A	15	12	11	?	11	?
	B	15	15	11	?	11	?
	C	15	12	11	?	11	?
	D	-	-	11	?	11	?
	Unknown				27		12
Per section	Intake	6	16	8	8	8	1
	Chemistry	6	5	8	1	8	1
	Control room	6	6	8	5	8	3
	Release	6	5	8	3	8	1
	Shift leader	3	2	4	2	4	0
	Several		0		6		5
	Unknown		5		2		1

Note. Number of employed operators per section is based on work documents.

The response rate at the cutting department (Table 1) was relatively stable: 89% at t_{1a}, 66% at t_{1b}, and 69% at t_2. However, among the galvanizing operators, the response rate dropped drastically with every round (see Table 2). In t_{1a} we received 39 (87%) responses, in t_{1b} 27 (61%), and in t_2 only 12 (27%). The response drop between t_{1a} and t_{1b} was probably caused by reorganization. Initially, the galvanizing department consisted of 3 teams of 15 operators; after the reorganization, the operators were shuffled and relocated into 4 teams of 11 operators. This most likely caused the reduced pride with the team and perceived performance they reported in t_{1b} as compared to t_{1a} (see Table 3), resulting in decreased willingness to fill in a questionnaire about teamwork. The drops in pride and performance did not recover in t_2, which might partly explain the continued response dropout. Moreover, some shift leaders were replaced by interim shift leaders due to vacation, which might have reduced the commitment in completing the questionnaire as well.

Table 1 and Table 2 also show the incomplete data we received regarding teams and sections. From the cutting teams, all data were available in t_{1a}, yet at the galvanizing department, several operators had not filled in the section where they worked. In t_{1b}, the completed questionnaires from different teams at the galvanizing department got mixed up and several participants had not indicated at which section they had worked. In t_2, the team data were not available at either department. Due to the missing data, we could not trace back individuals; hence, we could only analyze effects of the interventions using averages of the whole department.

Table 3. Means of Pride, Interdependence, and Performance in t_{1a}, t_{1b} and t_2 with Significance of Variation Over Time.

Cutting department	t_{1a}	t_{1b}	t_2	**sig.**
Pride with the team	4.41	4.18	4.29	n.s.
Perceived team performance	4.50	4.17*	4.61*	.021
Perceived interdependence††	2.95	3.14	3.53†	n.s.
Perceived hindering††	1.54	1.92	2.19	n.s.
Perceived helping††	3.72	3.60	4.04†	n.s.
Galvanizing department	t_{1a}	t_{1b}	t_2	**sig.**
Pride with the team	4.54	4.00	4.00	n.s.
Perceived team performance	4.54	4.13	4.18	n.s.
Perceived interdependence††	3.13	3.20	3.28†	n.s.
Perceived hindering††	1.59	1.95	2.23	n.s.
Perceived helping††	3.29	3.50	3.51†	n.s.

Note. *Significant difference between t_{1b} and t_2 ($p < .05$); †Significant difference between departments ($p < .05$); †† No significant differences between sections ($p > .05$).

RESULTS

Before discussing the results of the study we analyze the possible effect of extraneous variables. After that we will describe the results of study 1 and study 2, ending with the operators' opinions regarding the screens.

Extraneous Variables

We used the t_{1a} data to estimate the effect of extraneous variables, such as the above-described reorganization that seemed to influence galvanizing operators' pride with the team and perceived performance. Most data were not normally distributed and we assumed that those who participated in t_{1b} had also participated in t_{1a}. Hence, Wilcoxon signed-rank tests were used to evaluate whether there were significant differences between t_{1a} and t_{1b} within the two departments. The results revealed no significant difference in any of the measured variables in either department.

Overall, the t_{1a} data suggest that all measured variables are already high at the factory (see Figures 14a-b, 15a-b & 16a-b and Table 3). Consequently, we could expect a ceiling effect and thus small-to-no effects of the interventions. Only the nonwork-related conversation response for the galvanizing department was moderate (see Figure 14a). Mann-Whitney tests were used to compare the questionnaire answers of the two departments in t_{1a}. As expected, the results indicated that galvanizing operators in t_{1a} had less nonwork-related conversation (*Mdn* = 3; see Figure 14a) than cutting operators (*Mdn* = 4; see Figure 14b), U = 372.0, p = .019, r = .39. Thus, we mainly expected to find an effect in nonwork-related conversation at the galvanizing department.

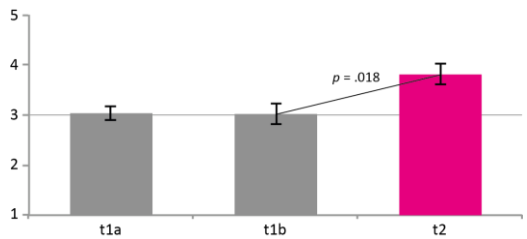

Figure 14a. (Study 2) Average self-reported nonwork-related conversations among galvanizing operators increased significantly after implementing gamified personal profile information.

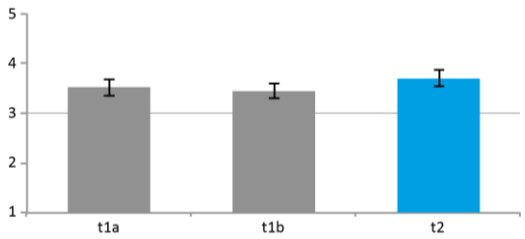

Figure 14b. (Study 1) Average self-reported nonwork-related conversations between cutting operators increased slightly over the course of the study.

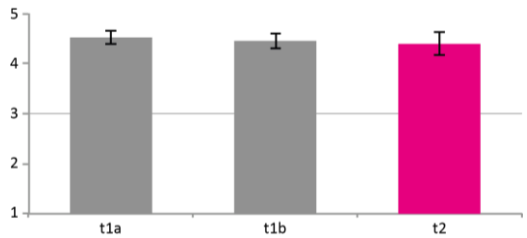

Figure 15a. (Study 2) Average self-reported commitment to team goals among galvanizing department operators.

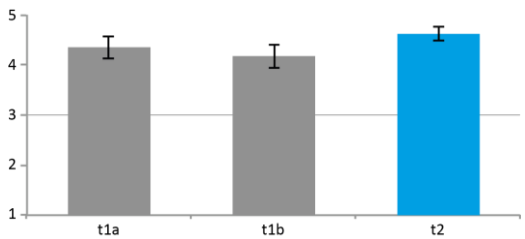

Figure 15b. (Study 1) Average self-reported commitment to team goals among cutting department operators.

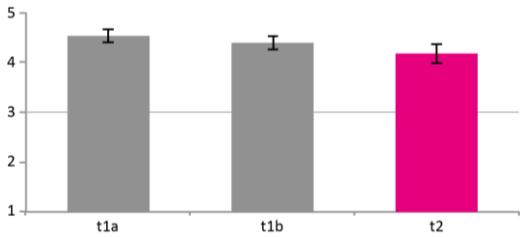

Figure 16a. (Study 2) Average self-reported commitment to team tasks dropped over the course of the study among galvanizing operators.

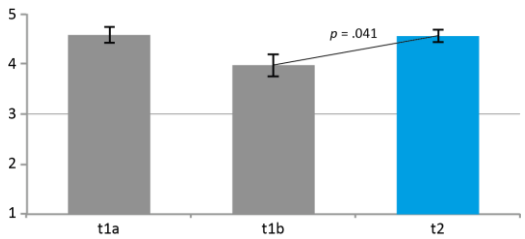

Figure 16b. (Study 1) Average self-reported commitment to team tasks among cutting operators increased significantly after implementing a screen with gamified KPI information.

Kruskal-Wallis tests were computed to evaluate whether operators from different teams and sections had different teamwork experiences in t_{1a} (and t_{1b} at the cutting department). In the cutting department, teams differed significantly in their commitment to team goals in t_{1b}, χ^2 (4, N = 22) = 9.31, p = .037. Post-hoc analysis using Mann-Whitney tests comparing goal commitment per team revealed that operators at one team reported significantly lower commitment to team goals (*Mdn* = 3) than operators from the other teams (*Mdn* = 4). In the galvanizing department at t_{1a}, teams differed in pride with the team, χ^2 (2, N = 35) = 9.24, p = .007, and perceived team performance, χ^2 (2, N = 35) = 7.01, p = .024. Posthoc analysis revealed that one team scored significantly lower on both variables (*Mdn* = 4) than the other two teams (*Mdn* = 5). In both departments, there were no significant differences between sections. Thus, in conclusion, teams were expected to be an extraneous factor for measuring commitment to goals in the cutting department and for measuring pride and performance in the galvanizing department.

Study 1: KPI Screen for Task Cohesion in the Cutting Department

Figures 14b, 15b & 16b and Table 3 depict the data gathered by the questionnaires in the cutting department. To examine the effect of the KPI screen on task cohesion in the cutting department, commitment to team goals (Figure 15b) and team tasks (Figure 16b) in t_{1b} were compared with the commitment in t_2. Because the data at t_{1b} and t_2 were not normally distributed, we used Wilcoxon signed-rank tests to evaluate whether task cohesion differed between t_{1b} and t_2. The results indicated that commitment to team tasks was significantly greater at t_2 (*Mdn* = 5) than in t_{1b} (*Mdn* = 4), Z = -2.043, p = .041. Figure 14a also suggests more commitment to goals at t_2, although no significant effect was found, Z = -1.852, p = .064.

All other variables were examined through Wilcoxon signed-rank tests as well because they also were not normally distributed. The results indicated that the median t_{1b} scores (*Mdn* = 4) of team performance were statistically significantly lower than the median t_2 scores (*Mdn* = 5), Z = -2.308, p = .021. As shown in Table 3, nonwork-related conversation, pride, interdependence, hindering, and helping revealed no significant effects. Thus, the KPI screen seems to have increased the cutting teams' commitment to tasks and perceived team performance.

Study 2: Personal Profiles for Informal Conversations and Interdependence

To examine the effect of the additional personal profile pages, nonwork-related conversation (Figure 14a) and experienced- and behavioral interdependence (i.e., hindering and helping)

(Table 3) in the galvanizing department at t_{1b} were compared with nonwork conversation and interdependence at t_2. The data on nonwork conversation in t_{1b} and t_2 were not normally distributed, thus nonparametric Wilcoxon signed-rank tests were used to compare the scores of t_{1b} and t_2. The results indicated that nonwork-related conversation was significantly greater at t_2 (*Mdn* = 4) than at t_{1b} (*Mdn* = 3), $Z = -2.356$, $p = .018$. Regarding experienced- and behavioral interdependence independent samples, *t* tests were computed, as the data were normally distributed; yet no significant differences were found. Thus, from all measured variables, the additional personal profiles seem to have only increased nonwork-related conversation in the galvanizing department.

Opinions about the Interventions

The analysis of the questionnaire data regarding the operators' attitudes towards the screens indicated that galvanizing operators found the screen significantly more important at t_{1a} (*Mdn* = 4) than at t_2 (*Mdn* = 3), $U = 121.5$, $p = .049$, $r = .29$. Moreover, at t_2 the importance of the screen was rated significantly lower by galvanizing operators ($Mdn_{galv} = 3$) than by cutting operators ($Mdn_{cut} = 4.5$) $U = 61.0$, $p = .017$, $r = .42$. Among the galvanizing operators, the screens gradually became less important over time ($M_{t1a} = 3.64$, $M_{t1b} = 3.08$, $M_{t2} = 2.73$), whereas their attention toward it remained stable (*Mdn* = 3; once a week). Among cutting operators, importance and attention to the KPI information on their screen (*Mdn* = 3; once a week) remained the same at all measurement times.

After surveying the operators in t_2, 11 galvanizing operators from different sections and teams were interviewed, including shift leaders, to gain a better understanding of their attitudes towards the game elements on the screens. In the interviews, shift leaders said they regularly browsed through the detail pages of KPIs; operators reported they sometimes browsed through them at lunchtime or before starting their shift but primarily glanced at the overview page. During the intervention period, 790 clicks on the details button were measured, which averages 6 clicks per day. All operators indicated that the KPI information was useful. One shift leader explained that the infographics made him discuss the calculation of some KPIs with the management.

All interviewees also indicated they were familiar with the personal profiles (43 clicks per day were measured), yet not all knew every bit of information that it contained. Interestingly, the personal information was known by nearly all of them (10 out of 11), probably due to the complaints about displaying personal information when they were introduced. The operators were generally negative about the information on their profiles because they considered it to be incorrect. Most interviewees were not aware of the fact that the information regarding hobbies and interests came from answers that colleagues gave through the pop-up statements. Just one operator mentioned that he sometimes had a look at his profile to see what his colleagues had answered about him. However, most operators had not understood the link. This may be explained by the fact that fewer than half of them had seen the pop-up statements, which is also reflected in the low rate of 4 clicks on average per day. Consequently, operators mentioned they would like to have more control over the information in their own profile, for example, to remove hobbies and interests that offended them.

The operators who had seen the pop-up statements indicated that they found it strange that the statements were about colleagues from the team that was leaving. At the end of a shift, statements popped up about the operators who had just completed a shift, whereas operators

who were starting their shift mainly took some time to look at the screen. As a consequence, operators from the arriving team often answered statements about operators from the departing team. Instead of using the statements as input for the personal profiles, operators suggested a preference for questions that challenged their knowledge about each other.

Regarding the visualization of an operator's roles within the team, interviewees were generally positive. They considered it to be useful information, even though nearly all interviewed operators stated that they already knew each other's skills and experience. One operator mentioned, "*I wonder why some of my colleagues have so many colored operator figures, even though they haven't worked here as long as I do. Why do I not get any additional operator figures* [referring to roles in the process]?" This suggests that the operator figures were correctly understood and raise awareness about one's contribution to the team. The badges were also positively received. Operators who had seen them (4 out of 11) considered birthday and anniversary information useful to know. One shift leader recommended adding functional badges, such as an emergency response badge.

In general, all work-related information on the screen received positive responses. However, most of the personal information was received with indifference or a negative reaction.

DISCUSSION

This article presented the explicit application of game elements at a strip galvanizing plant to enhance team cohesion within production teams. The effects of two game design interventions were measured in two separate studies. In Study 1, a screen was introduced that displayed real-time game-like infographics about KPIs to increase the operators' commitment to team goals and team tasks (H1). The study contained three measurement times: priming (t_{1a}), baseline (t_{1b}), and postintervention (t_2) measures at which operators completed the same questionnaire regarding their teamwork experiences. The results revealed a significant increase of commitment to team tasks and perceived performance from t_{1b} to t_2.

At the same time in Study 2, gamified personal profile pages were added to already present KPI screens at another production department (galvanization). The profiles contained personal information (partly filled in by colleagues) and displayed one's roles in the team, information aimed at stimulating informal conversations and the feeling of interdependence among the operators. To measure an effect, the same study setup as in Study 1 was used. Results revealed that after introducing personal profiles, informal conversations increased significantly. Yet in both studies, overall team cohesion, interdependence and perceived team performance did not change significantly.

Overall, the quantitative results indicate no deterioration but possibly some improvement of the teamwork experience after implementing the game design interventions. Qualitative results with galvanizing department operators suggest that the game elements affected some operators in their perception of their work within their production team.

To what extent the interventions can account for the above-described effects remains uncertain, even though the analysis of variations between t_{1a} and t_{1b} did not reveal any significant variations that suggest other influences. The increase in informal conversations after the intervention in Study 2 (in the galvanizing department) was the most convincing result. Yet the dropout rate (73%) by the intervention measure (t_2) reduces internal validity. Responses at

t_2 do seem representative for the whole group, in that results on other variables (e.g., pride with the team and perceived team performance) resemble results from t_{1b}. This also suggests that the influence of daily events was probably negligible. When inspecting individual reports on nonwork-related conversation among galvanizing operators, we mainly found an absence of low ratings in t_2, which might indicate selection bias. On the other hand, the number of subjects reporting a high rating increased by one. Due to incomplete data, we could only trace back four individuals across all measurement times. Hence, significant correlations between measurement times could not be computed.

The effects from the galvanizing department's reorganization was apparent in the drop in pride with the team and perceived team performance between t_{1a} and t_{1b}, suggesting that the self-reports were genuine. Due to the changed composition of the teams and fewer shifts per team to achieve their team targets, performance markers obviously decreased. This was recognized by the operators and appeared to affect their feeling of pride with the team. Although the reorganization took place only in the galvanizing department, it probably affected both departments. However, the cutting operators seemed to recover by t_2.

As we clearly measured different effects in the two departments, the operators seem not to have been influenced by the intervention in the other department. Moreover, the attitude of the galvanizing operators toward the screens seems not to have been a significant influence on the effects because operators were relatively negative towards the personal information. Nonetheless, their nonwork-related conversation increased.

In retrospect, it would have been useful to also ask for the operators' feelings regarding their contribution to the team. Initially, the corresponding game elements (operator figures on the production line graphic) were intended to increase perceived interdependence, yet it is probably the factory's system factors that mainly influence these variables. Consequently, contribution visualization did not lead to significant differences in interdependence, although the interviews suggest that we could expect an increase in perceived contribution to the team.

The fact that no significant differences were measured in team cohesion and perceived team performance may have been caused by a ceiling effect or the timeframe in which they were measured. In both studies, the operators already gave high ratings for cohesion and performance in the prime and baseline measures; hence, there was not much room for improvement. Moreover, the timeframe (6 months) and number of measurements (three) might have not been appropriate for these variables. To measure perceived performance and cohesion, more measures may be needed over a longer period of time to overcome the effect of daily events and changes in the organization.

Another way to better measure team cohesion would be to define all underlying factors by group-level statements (Gully et al., 2012; e.g., "The team was committed to its tasks" instead of "I was committed to the team's tasks"). In this way, the underlying factors could provide an indication for overall team cohesion.

CONCLUSIONS

From our study we derived several lessons. We will first describe the lessons learned focusing on designing and implementing the intervention, followed by the lessons learned regarding the research design.

Lessons Learned: Game Design Interventions for Team Cohesion

Although the significance of the results in both studies is debatable, all effects hint toward a similar conclusion. The game design interventions seem to have affected only the operators' perception regarding topics that were directly addressed in the game elements. In Study 1, infographics about the team's performance improved the operators' commitment to their tasks and perception of their performance, and in Study 2, informal information stimulated informal conversations. Hence, the game design interventions appear to be successful in raising attention for particular topics.

Consequently, we suggest that developing gamification concepts is mainly a matter of making the implicit elements in the work explicit in the form of game elements, such as making performance explicit in the form of performance feedback. This is similar to what has been done in the majority of gamification studies that have been published recently (e.g., Hamari et al., 2014). Other elements, such as interdependencies within a team, could be made explicit as well. For example, one could try to make explicit the implicit conflict between the intake and control room operators, as described in the user–context analysis. Presumably, such additional interventions could raise understanding for each other's situation.

The research framework in Figure 3 proved to be a good basis for developing game elements for teamwork and suggests several opportunities in addition to the interventions that were investigated in our studies. For example, the framework suggests that to increase team cohesion, game elements should address attraction to the team. We suggested a number of solutions for that. For example, we proposed aligning individual interests with company interests by putting up banners in the production hall, displaying how the factory's clients use the coils and how this contributes to people's daily lives (e.g., relating how kilometers of guardrail saves thousands of lives each year). Another idea was to make operators clock in at the screen so they could see their image at the bottom and their operator figure appears on the production line image. Moreover, displaying the implemented pages on the operators' monitors could have increased their attention for it. However, the company's management considered these interventions to be too invasive.

In general, the operators' engagement with the elements could be improved. The interview results suggest that primarily shift leaders browse through details regarding KPIs, and operators would prefer more control over their profiles. In the current intervention, they could not directly play or interact with the introduced elements. As a result, their engagement with the elements probably was not optimal. The lack of interactivity is a problem not only in our study but in most gamification studies. Gamification is often intended just to inform users in a more stimulating manner rather than increasing the user's control over the presented elements (Hamari, 2013; Mekler et al., 2013; Mollick & Rothbard, 2013).

Moreover, moderate engagement with the screens might have been caused by the focus on team factors. As explained earlier, workers tend to focus on measures for which they are directly rewarded (Mendibil & MacBryde, 2006), which, in this case, was not the team performance. Hence, introducing game elements that directly reward team performance could improve the operators' engagement with the screens. A more drastic approach would be to relate their salary to the team's or company's performance.

This leads to our final lesson in developing game design interventions for team cohesion: organizational transparency. The game elements seemed to expose the system and strategy of the company. For example, in the cutting department, client complaints were explicitly

visualized but are presented via the KPI client satisfaction component instead of more precise alternative wording such as client complaints. However, this was the first iteration of gamifying the KPIs for the cutting department. Thus, we recommend a redesign of the page to report client satisfaction, terminology that would probably be more motivating for the operators. In the galvanizing department, such iterations have been made, resulting in the racing cars visuals. In conclusion, we propose that an important quality of gamification is to expose rather than mask existing elements of work. Therefore, we recommend transforming existing work elements into game elements, rather than adding game elements to a nongame teamwork situation, such as a point system representing a measure that initially was not yet present.

Lessons Learned: Research Design

Team cohesion was found to be a good source of inspiration for the design of game elements for teamwork. Yet measuring an effect of the designed game elements in the complex context of production teams at a factory was more difficult than anticipated in application. We had to deal with a serious dropout rate over the three data collection points. Following our lessons on gamification, one way to reduce dropout could be to transform the measurement tool into a game element. This could imply making it easier and more fun to fill in a questionnaire. Additionally it could be tailored to the context, for example, through pop-up questions throughout the workday.

The fact that implicit elements were made explicit allowed for the integration of evaluative procedures within game elements. Instead of measuring the effect externally, game elements themselves could have provided data for evaluation. For the KPI information, this is already inherently present. However, regarding one's contribution to the team and informal conversations, this would be possible as well. One suggestion would be that the operator figures are also used as a measure to evaluate shifts in the operators' roles over time. To measure the operators' interest in a particular topic through game data, interactivity is crucial. The amount of interaction could say something about the attention for a topic, as the measured number of clicks in the present study demonstrates.

Future Work

The research framework (Figure 3) suggests several options for future work. Game elements for measuring attraction to the team could be investigated, as well as game elements that explicitly address team cohesion or team processes. We posit that by implementing more such interventions in a teamwork context, significant effects could trickle down to the team's performance.

Given the current status of research on gamification, an interesting follow-up question would be can individual game-like incentive mechanisms increase engagement with teamwork processes? Most gamification experiments are based on individual incentives for individual activities (Hamari et al., 2014). However, at most companies the work is done by teams. Thus investigating game elements explicitly for teamwork is needed. When following the gamification approach of making implicit elements explicit, this would require an analysis of the dynamics in the teamwork context. If we researchers and designers want to improve collaboration within teams, we need to select specific factors within the collaborative process and address them directly through game elements. For example, complimenting each other could be made explicit by giving each other points. Over time and with a diversity of design

research, the field will gradually uncover clear design and game elements that prove to be effective in achieving team cohesion.

Final Word

The operators of the galvanizing plant seemed more autonomous than the workers in the 1950s (see Roy, 1959), yet they are still supervised by a shift leader. Moreover, the automated production line challenges the operators' autonomy in their work. When all implicit elements in the operators' jobs become explicit, they could gain more control over their activities and become more accountable for their performances, either as individuals or as members of a team. Eventually this could lead to factories where operators fully run it by themselves. But first, the operators should get the feeling of operating a huge factory and producing tons of steel with a small operating team. The game elements that are presented in this paper may be a small step towards this ideal experience.

IMPLICATIONS FOR THEORY AND APPLICATION

Currently, the field of gamification primarily focuses on individual motivation. This article provides a framework for the design of game elements for collective motivation, which could pave the road for future research and applications of teamwork gamification. Our study suggests that we need further investigation of the impact of organizational processes for both team members and the team as a whole. We suggest that team cohesion and interdependence are fundamental dimensions of teamwork that are well suited for gamification and thus important factors for investigating the gamification of organizational processes.

In two intervention studies, we showed how the theory of team cohesion could be translated into actual game elements on a factory work floor. The results confirm earlier studies, demonstrating moderate positive effects of gamification. Yet, as it is a young research field, drawing lessons from these applied cases is most important. Our main finding is that gamification successfully drew attention to elements that are explicitly presented. Yet, as gamification designers, we have to become more sensitive to the impact of increased transparency as a result of gamifying particular aspects of individual workers and allow more control by the workers over the content.

Future research of gamified interventions should address the effect of specific design decisions on the behaviors and experiences of workers in teams. Our studies suggest that long-term exposure, individual acceptance, and adaptation to the context and users are crucial in studying the effect of gamification of teamwork.

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Appendix

Questionnaire (Translated from Dutch by the authors)

This questionnaire was distributed to all operators of the strip galvanizing plant three times. The sections used in this Appendix were for the galvanizing department. Operators from the cutting department received the same questions adapted for their sections. In the first questionnaire "in the past weeks" was replaced by "yesterday."

Could you indicate to what extent you agree or disagree with the statements below regarding **your work within the team** in the past weeks.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
In the past weeks, I felt as if the team was divided into separate **islands**.	☐	☐	☐	☐	☐
In the past weeks, reaching the **goals** of the team was important to me.	☐	☐	☐	☐	☐
In the past weeks, executing **all tasks** of the team was important to me.	☐	☐	☐	☐	☐
In the past weeks, the team **performed well**.	☐	☐	☐	☐	☐
In the past weeks, I felt **proud** of the team.	☐	☐	☐	☐	☐

Could you describe some of the **performances of the team**?

	Never	Rarely	Once in a while	Regularly	Often
In the past weeks, I […] talked to my colleagues about **nonwork related topics**.	☐	☐	☐	☐	☐

(If applicable) Could you describe some **nonwork related topics** that you talked about with your colleagues?

(encircle one of the options below)

In the past weeks, I worked at **section**… INTAKE RELEASE CHEMISTRY CONTROL ROOM

Could you indicate to what extent you agree or disagree with the statements below regarding the **collaboration with your colleagues** in the sections in which you worked during the past weeks. The statements are the same for each section.

INTAKE	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The activities of my colleagues at the intake section were **hindering my work** in the past weeks.	☐	☐	☐	☐	☐
My activities were **hindering the work of my colleagues** at the intake section in the past weeks.	☐	☐	☐	☐	☐
My colleagues at the intake section **have done something in favor of my work** in the past weeks.	☐	☐	☐	☐	☐
I have done something for the work of my colleagues at the intake section in the past weeks.	☐	☐	☐	☐	☐
My activities **depended on activities of my colleagues** at the intake section in the past weeks.	☐	☐	☐	☐	☐
Activities of my colleagues at the intake section **depended on my activities** in the past weeks.	☐	☐	☐	☐	☐
RELEASE					
The activities of my colleagues at the release section were **hindering my work** in the past weeks.	☐	☐	☐	☐	☐
My activities were **hindering the work of my colleagues** at the release section in the past weeks.	☐	☐	☐	☐	☐
My colleagues at the release section **have done something in favor of my work** in the past weeks.	☐	☐	☐	☐	☐
I have done something for the work of my colleagues at the release section in the past weeks.	☐	☐	☐	☐	☐
My activities **depended on activities of my colleagues** at the release section in the past weeks.	☐	☐	☐	☐	☐
Activities of my colleagues at the release section **depended on my activities** in the past weeks.	☐	☐	☐	☐	☐
CHEMISTRY					
The activities of my colleagues at the chemistry section were **hindering my work** in the past weeks.	☐	☐	☐	☐	☐
My activities were **hindering the work of my colleagues** at the chemistry section in the past weeks.	☐	☐	☐	☐	☐
My colleagues at the chemistry section **have done something in favor of my work** in the past weeks.	☐	☐	☐	☐	☐
I have done something for the work of my colleagues at the chemistry section in the past weeks.	☐	☐	☐	☐	☐
My activities **depended on activities of my colleagues** at the chemistry section in the past weeks.	☐	☐	☐	☐	☐
Activities of my colleagues at the chemistry section **depended on my activities** in the past weeks.	☐	☐	☐	☐	☐

CONTROL ROOM	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The activities of my colleagues at the control room were **hindering my work** in the past weeks.	☐	☐	☐	☐	☐
My activities were **hindering the work of my colleagues** at the control room in the past weeks.	☐	☐	☐	☐	☐
My colleagues at the control room **have done something in favor of my work** in the past weeks.	☐	☐	☐	☐	☐
I have done something for the work of my colleagues at the control room in the past weeks.	☐	☐	☐	☐	☐
My activities **depended on activities of my colleagues** at the control room in the past weeks.	☐	☐	☐	☐	☐
Activities of my colleagues at the control room **depended on my activities** in the past weeks.	☐	☐	☐	☐	☐

Below, several statements are presented regarding the **touch screen** and your work in general.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I find it **important** to have a touch screen.	☐	☐	☐	☐	☐

	Never	Once a month	Once a week	Once a day	Nearly every hour
I **look** […] at the touch screen.	☐	☐	☐	☐	☐

I have ……..…… years employed at WSN.

I have ……..…… years employed in general.

End of the questionnaire. Thank you very much for your cooperation.