Abstract

This paper examines the influence of goal-setting on worker performance in an industrial production process. For empirical examination, we conducted a real-effort experiment at the Training Factory for Energy Productivity at the Technische Universität München. The participants’ performance was measured by checking for quantity and quality of the assembled products and furthermore by recording the consumed compressed air per finished good. In total four groups were defined, each group in a different experimental setting. This experiment is the first one ever conducted related to goal-setting in an industrial production setting and thus adds valuable results to academia and practitioners in the field of sustainable manufacturing. The major results are that even without financial incentives goal-setting improves worker performance by 12 to 15% compared to the situation where no goals were defined. This holds true for the groups which had to maximize either output quantity or output quality, as well as for the group which was obliged to be as energy efficient as possible.

Keywords: goal-setting; sustainable manufacturing; industrial production

1. Introduction

Every relationship between a principle and an agent is characterized by information asymmetry [1,2]. Since the employer is not able to monitor the effort of the employees permanently, certain measures to motivate the staff have to be offered to the workforce. One suitable way to motivate is to set goals [3]. The implementation of goals in everyday work is manifold starting with sales goals for marketing managers or production goals for blue collar worker in industrial production [4]. From a research perspective, the impact of goal-setting on human behavior is an interesting and already well-examined topic. Starting in the late 1960’s [5,6], studies focused on the effect of consciously set goals on the performance of individuals with a major focus on the number of solved tasks or produced units within a certain time frame. Thereby most of the experimental studies focused on daily office tasks like telephone services [7] or typing [8]. What has not been observed so far, is the effect of goal-setting on real production tasks. Furthermore there is only little knowledge about the impact of setting goals related to other goal dimensions than output quantity. Given the above, the presented study is examining if the findings of previous studies about goal-setting are applicable to a real industrial production setting and furthermore transferable explicitly to other goal dimensions, in this case output quality and energy efficiency as two of the major goals in modern production.

2. Literature and Hypotheses

The goal-setting theory is strongly affected by Ryan’s [9] assumption that human behavior is driven by objectives, so-called goals [10]. Taking this relationship into account, primarily Latham and Locke [10,11,12], among others, focused their research on the link between consciously set goals and the observable task performance of individuals. Thereby their major interest was on explaining and forecasting human performance on several types of tasks and furthermore on affecting someone’s performance by different
types of measures [10]. The findings of numerous experimental studies show that goal-setting strongly influences human behavior and thus leads to changes in performance [13,14,15,16]. This holds true for varying tasks, different groups of participants and diverse experimental settings. However, so far goal-setting in industrial production processes is not well-examined. Based on the results of previous experimental studies in non-production settings hypothesis 1 is as follows:

**H1:** Goal-setting improves task performance in an industrial production setting.

Our study not only aims to examine the effects of goal-setting in industrial production, but moreover to distinguish sharply the effects of goal-setting on different kind of goal dimensions. The main focus of previous studies was on the measure of the impact of goal-setting on task quantity, mostly defined as the time needed to perform a certain task, either doing calculations [5], specific reading tasks [14] or reacting on a signal light [17]. The effects of goal-setting on other important goal dimensions like output quality have not been neglected. Energy consumption as an important factor for industrial production processes, so far has not been examined within a goal-setting situation. Hence, to strengthen the explanatory power of goal-setting theory in a production setting, the presented experiment focuses on the impact of goal-setting on the three described goal dimensions, output quantity, output quality and energy consumption. Therefore the sub-hypotheses of H1 are as follows:

**H1a:** Goal-setting increases the output quantity.

**H1b:** Goal-setting increases the output quality.

**H1c:** Goal-setting decreases the consumed energy per output unit.

In 1990, Locke & Latham introduced the High Performance Cycle (HPC) [18] which integrates the essential elements of goal-setting theory as shown in figure 1.

![Fig. 1. The High Performance Cycle (HPC).](image)

While specificity and difficulty as the goal core dimensions as well as certain moderators and mechanisms influence the performance, the potential achievements e.g. productivity or cost improvement have a strong impact on the individuals’ satisfaction and the willingness to cope with challenging tasks and objectives in the future [10,18]. Both difficulty and specificity have been investigated extensively. Several empirical studies show that the higher the difficulty of a goal is, the higher is the performance of the individuals that executed the task [13,16]. Notably, a performance increase is only possible, until the limit of a persons’ ability is reached [19]. Experiments show that specific goals lead to greater achievements compared to non-specified or vague defined goals [13,17]. Therefore so-called ‘do-your-best-goals’ are not sufficient to generate optimal performance [12,16]. However, since specific goal-setting is not always easy to implement, for instance due to a lack of information about the potential range of performance outcomes, even broadly formulated goals like maximizing the output or minimizing the input can lead to significantly improved performance. Due to the design of this experiment, our formulated goals are not specified further than maximizing the output quantity, maximizing the number of assembled goods having a defined quality level and using as little energy as possible to perform the task.

As one of the four mechanisms, persistence is integrated as a potential mediator on task performance in the High Performance Cycle [10,18]. In this regard, persistence can be interpreted as an indicator for the development of task performance over time or as a potential proxy how people change their effort level due to certain time constraints while performing a task. As already empirically proven, people extend their effort when having tight time constraints compared to situations with loose deadlines [5,11].

Based on the power curve model of Wright [20] and innumerable other approaches to show and explain learning curves, it is known that people are able to improve their performance over time when doing repeated tasks. Furthermore Dar-el et al. [21] found out that cognitive and motorial elements occur in different stages when learning industrial tasks through repetition. So far no clear evidence exists on the interaction of goal-setting and learning effects on task performance. Therefore it is of high interest, if goal-setting leads to changes in the development of task performance over time when performing repeated tasks due to occurring learning effects. To examine the described relationship, hypothesis 2 is as follows:

**H2:** Goal-setting intensifies learning effects and leads therefore to additional task performance improvement when doing repeated tasks.

### 3. Method

#### 3.1. Experimental setting

Between July and August 2013 the presented experiment was conducted at the Training Factory for Energy Productivity at the Technische Universität München, Munich, Germany. Since the production line of the training factory used as the setting for this experiment is quite similar to real industrial production, this experiment combines elements of economic laboratory and field experiments. Because
comparability of participants’ performance should be as high as possible, we chose the final step of the whole production chain as the setting for the experiment, where participants were asked to assemble gearboxes. This process step ensured the highest controllability of external parameters.

3.2. Participants

We invited 120 subjects, who were assigned to four different treatment groups. More than 95% of the participants were regular bachelor and master students of the two major Munich universities with an average age of 24 years. To ensure high comparability of the subject pools of the four groups, the share of females was held equal between 20.00 and 23.33% in each group. Besides the set gender distribution, participants were randomly assigned to the groups. With about 92% of all subjects, the vast majority was right-handed. Furthermore it was possible to adjust the used pneumatic screwdriver for left or right-hand-use. Therefore no distinction respectively special allocation to the groups based on the handedness was made.

3.3. Task and goals

All participants were provided with the same workplace. To assemble the gearboxes, the workplace was equipped with a pneumatic screwdriver to screw bolts into the gearboxes (six bolts per gearbox), 16 unassembled gearboxes, a large number of bolts, a flow meter which displayed the accumulated consumed compressed air, a pressure balancer to control the pressure level of the pneumatic screwdriver, as well as a digital torque wrench to check the torque level of the bolts in the assembled gearboxes.

For evaluating participants’ performance, the number of screwed bolts, the consumed compressed air, as well as the average torque reach level of each assembled gearbox were measured and noted down after each round. Based on the treatment group participants were assigned to, they were asked upfront to achieve certain goals as already described in detail:

Group 1 (Control Group) - No goal.
Group 2 (Quantity Group) – Quantity maximization
Group 3 (Quality Group) – Quality maximization.
Group 4 (Energy Group) – Energy consumption minimization.

As it can be seen above, group 1 as the control group, had no goal to achieve, while group 2, 3 and 4 each had one defined goal. The goal of group 2 was the maximization of the output, measured through the number of assembled gearboxes and the thereby installed bolts. The goal of group 4 was the minimization of the input factor compressed air while performing the assembly task. The goal of group 3 was more complicated to formulate for that experiment, because the potential measures for quality in production are both manifold and difficult to implement. Finally the quality goal was set as reaching an average bolt torque of 2.0 to 2.5 Nm for every assembled gearbox and its six bolts. This level was set for two reasons: on the one hand side to avoid potential releasing of the bolts after a certain operating time due to a too low bolt torque, on the other hand side to avoid potential damages to the bolts and gearboxes due to a too high bolt torque.

3.4. Procedure

As already described, the presented part of the experiment consisted of four different experimental groups. As it can be seen in figure 2, the sequence of the experiment was equal to all participants.

![Sequence of the experiment](Fig. 2. Sequence of the experiment.)

First of all a presentation and a video with a detailed description of the task to perform, the workplace and the available equipment had been shown. Subsequently a trial round of five minutes started, in which participants should become acquainted to the task. After that trial round again a presentation was shown to familiarize participants even more with the equipment available, to evaluate first own experiences of the trial round and to clarify open questions. Subsequently, the first round with a duration of five minutes started, followed by a break of one minute. After that, the same procedure as in round 1 started with the beginning of the second round, followed again by a one minute break and finally followed by the third and last round of the experiment. While participants had the chance to use the breaks to relax, the experimentator wrote down the results of all three goal dimensions of the previous period on a scoring sheet.

After the final round all participants were provided with a questionnaire asking for demographics and task-related information. After finishing this questionnaire, participants got paid their fixed compensation of 9€. Based on how fast participants clicked through the presentations and filled out the questions at the end, the total duration of the experiment was between 40 and 55 minutes.

By showing presentations and videos to the participants instead of letting the content be explained by the experimentator, a highly standardized process for all participants was secured, avoiding for instance influences resulting from even unintentionally change of experimentator
behavior from one participant to another and securing that every participant got every information presented from the same perspective and in the same sequence. The only difference between group 1, having no goal and the other three groups each having one goal defined, was that in the presentations before every round, except of the trial round, one slide explicitly mentioned the particular goal of that group. No goal was mentioned to group 1, maximizing the output to group 2, reaching the particular average bolt torque for as many as possible assembled gearboxes to group 3 and minimizing the used compressed air per assembled gearbox respectively per bolt to group 4.

4. Results

4.1. The influence of goal-setting on task performance

For testing the first hypothesis about the general influence of goal-setting on task performance, three two-sample t-tests with equal variances had been conducted to test for significant differences of the performance outcomes between the groups. In the following, the results regarding the three sub-hypotheses of H1 will be described and visualized for the corresponding treatment group compared to the control group (group 1).

In case of output quantity as the first goal dimension, the results of group 1 are compared to group 2, as the group with the goal of assembling as many gearboxes as possible in the given time. With t(58) = -3.1862, p < .01, group 2, as the one with the quantity objective, shows a significantly higher performance than group 1 with no objective. Figure 3 visualizes the total number of bolts subsumed over all three rounds comparing both groups. While the participants of group 1 reached on average a total number of 88.6 bolts, group 2 generated with 101.1 bolts more than 15% more output in the three rounds.

Fig. 3. Comparison of the means of the total number of bolts over three rounds for group 1 and 2.

Comparing the influence of goal-setting on task performance regarding output quality, group 1 with no objective and group 3 as the one with the quality objective are taken into account. With t(58) = -0.5001, p > .05 no significant difference between the groups does exist. With about 24.1% target achievement, the group with the quality objective reached a slightly higher share compared to the control group with 21.5%, but not on a significant level.

To check whether or not goal-setting has a significant influence on the participants’ performance regarding the minimization of used compressed air for executing the task, the consumed compressed air per bolt is compared for group 1 and group 4. With t(58) = 5.9636, p < .001 the difference is highly significant. Group 4, as the group with the energy saving objective, consumed with 6.23 liter per bolt significantly less than group 1 which used on average 7.00 liter compressed air per bolt. The graphical results can be seen in figure 4, where the average consumed compressed air level per bolt over three rounds for group 1 and 4 are shown.

Fig. 4. Comparison of the means of consumed compressed air per bolt over three rounds for group 1 and 4.

Summarizing the results of hypothesis 1 and its sub-hypothesis, goal-setting in the given industrial production setting leads to a higher performance when subsuming the 3 experimental rounds. This counts for all three one-objective groups compared to the control group. Regardig the objectives output quantity and energy consumption, the differences are very, respectively highly significant, while for the quality goal the difference is not significant.

4.2. Goal-setting as an intensifier of learning effects when performing repeated tasks

We now examine if goal-setting intensifies learning effects and if therefore the change in task performance over the three rounds is different if a goal is given or not. For that reason, we ran panel regression analyses analyzing the performance change of the control group and the respective comparison group for every goal dimension.

First of all the change in produced quantity over the three experimental rounds had been compared between group 1 as the control group and group 2 as the group with the goal to maximize the output quantity. With F(1,59) = 7.71, p < .01, the F-statistics of the panel regression analysis shows that the control group increased the output quantity from round to round...
round significantly, with a coefficient of 1.42. With \( F(1,59) = 49.91, p < .001 \) group 2 increased the quantity as the considered performance indicator significantly too, having a much higher coefficient of 2.42. These results are visualized on the left part of figure 5 where the rounds are displayed on the x-axis while the number of bolts is shown on the y-axis. It becomes clear that regarding the quantity, goal-setting works as an intensifier of learning effects. Additionally it has to be mentioned that the model’s validity for group 2 is with \( R^2 = .4583 \) much higher than for group 1 with \( R^2 = .1156 \).

These results are visualized on the left part of figure 5 where the rounds are displayed on the x-axis while the number of bolts is shown on the y-axis. It becomes clear that regarding the quantity, goal-setting works as an intensifier of learning effects. Additionally it has to be mentioned that the model’s validity for group 2 is with \( R^2 = .4583 \) much higher than for group 1 with \( R^2 = .1156 \).

Fig. 5. Quantity and quality development over the three rounds comparing group 1 and group 2 for quantity and group 1 and group 3 for quality.

Figure 5 shows on the right hand side the development of the quality performance comparing group 1 and group 3. The rounds are again displayed on the x-axis and the target achievement in percent on the y-axis. It becomes clear that the control group had a less steep learning curve from round 1 to round 2 compared to the objective group, but both groups decreased in their performance from round 2 to round 3.

Taking a closer look on the performance development of group 1 and 4 related to the energy consumption, group 4 as the group with the objective to use as little compressed air as possible started in round 1 on a much lower consumption level compared to the group 1 and had stronger learning effects from round 1 to round 2 and from round 2 to round 3. Nonetheless the learning effects of both groups are not significant as it is illustrated in figure 6. This figure displays the results of the panel regression with the rounds on the x-axes and the energy consumption per bolt on the y-axes.

To prove whether or not goal-setting leads to higher performance due to enhanced learning effects for the objectives quality and energy too, panel regression analysis for group 1 and the objective groups had been performed. Contrary to output quantity, no significant improvements based on learning effects over the three rounds did occur, neither for output quality nor for the energy consumption. Furthermore the validity of the models had been comparable low with \( R^2 = .0156 \) for the panel regression of group 1 regarding quality and \( R^2 = .0161 \) for group 3 regarding quality and \( R^2 = .0146 \) for the panel regression of group 1 related to energy and \( R^2 = .0535 \) for group 4.

5. Discussion

This experiment aimed to show the effect of goal-setting on human behavior. While this was already examined extensively in several experimental studies [13,15] mostly for output quantity as the measure of interest, other goal dimensions were not included extensively. Analyzing the results of the current study it becomes clear that our hypothesis suggesting that goal-setting improves task performance can be fully supported for the goal dimension output quantity. With a significant higher output for the quantity-objective group compared to the control group, the results are in accordance with the existing literature [22,23,24].

Regarding the goal dimension output quality, the results of the experiment go into the same direction. Even the performance differences between the control group and the quality-objective group are not significant, the objective group outperformed the control group by a 12% higher target achievement seen in relative numbers. Even though the target achievements are with 21.5% for the control group and 24.1% for the objective group comparable low, the relative performance difference between both groups is not negligible.

Of eminent importance, not only for the field of sustainable manufacturing, are the findings regarding the energy consumption goal. Comparing the results of group 1 as the control group and group 4 having the objective to use as less compressed air as possible to assemble the gear boxes, the objective group used with 6.23 liter compressed air per bolt significantly less than the control group with 7.00 liter per bolt. The results for all three different observed goal dimensions show that the goal-setting theory based on Latham & Locke [10,11,12] is also applicable to other goal dimensions than output quantity and works as well in an industrial production setting.

Analyzing the results of hypothesis 2 that goal-setting works as an intensifier of learning effects, a somewhat similar statement can be derived for all three goal dimensions. For the objective groups the learning curves of the participants appear steeper compared to the control group. While the performance
difference regarding quantity is significant comparing the control group and the quantity-objective group, the differences in the learning curves of energy consumption have been demonstrated clearly in a figure, but are not statistically significant. The same counts for the quality goal. While control group and quality-objective group both improved their level of task achievement from round 1 to round 2, their performance dropped down from round 2 to round 3. Even the performance increase to the second round was larger and the decrease in performance from the second to the third round smaller for the quality-objective group compared to the control group, the differences are not statistically significant.

For all three goal dimensions it can be concluded that goal-setting works as an intensifier of learning effects. The strongest reinforcement has been measured for the quantity goal.

6. Conclusion

First, this experiment aimed to assess if goal-setting theory is applicable to other goal dimensions than output quantity. Therefore output quality and energy consumption as further relevant goal dimensions where integrated into the experiment. Second, the experiment took place in a real industrial production setting to figure out, if positive effects of goal-setting are reproducible outside conventional experimental laboratories. From the results we can conclude that setting goals is one promising way to improve workers’ performance in industrial workplaces and that goal-setting theory is of high relevance even far beyond conventional set goals, being deployable to output quality and environmental objectives, too. Due to scarce resources and increasing market prices for energy, these results are of high relevance not only for producing companies but more globally seen for the well-being of our society. If the effects of goal-setting either on traditional or currently emerging goals can be intensified by incentives, has to be assessed in future research.

A further aim of the present study was about the impact of goal-setting. The results furthermore show that goal-setting had a positive impact on the learning process in industrial tasks. Specified goal level for every of the peoples who are confronted with certain goals. Even though it became clear that different goal dimensions should not be treated equally, this field has to undergo further research.

For the purpose of that study, the goals have not been specified further than maximizing the output quantity, reaching a certain quality level for as many as possible assembled goods and using as little energy as possible to perform the task. Specified goal level for every of the dimensions should allow further statements about the concrete impact of goal-setting.

References

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