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Learning by Using: the Learning of a New "Language"

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ABSTRACT: Using data from participant-observation and interviews addressing users of the largest CNC laser machine producer in the world, located in Europe, I investigate a cause that leads to cumulative learning with using. This cause differs from uncertainty in the prediction of performance characteristics or its need for improvement with growing certainty in the field. Drawing from theory and research on learning and problem solving, I introduce the concept of learning by using as the acquisition of a new language, wherein language is defined as the entire concept from latent logic to manifestations of this understanding, such as spoken words, actions or products. My empirical field evidence shows that the manufacturer and users speak fundamentally different languages, lacking adjustment to the logic of the other side. This refers especially to the cumulative utilization problems that exist beyond solving a product's teething problems. Data suggest that utilization experience is dominated by solution search in a non-linear process, eventually leading to recognition of manifestations of the different languages used and problem-solving, but lacks an adjustment to the different logical concepts. This leads to dissatisfaction in utilization and could be solved by trying to understand the root cause of the diverging manifestation so as to grasp the intention of the other side and be able to adapt their own logic to them. I discuss implications for theory and practice and provide suggestions for future research.

KEYWORDS: Learning by using, learning by doing, problem solving, innovation, learning, organizational learning

Introduction[i]

Recent fatal losses of Boeing's 737-8MAX aircrafts shed light on a theoretical concept lost in oblivion—learning by using. They are a reminder of the accidents that followed the use of the first commercial jet liner, the Comet, which changed modern aviation and engineering practices. In a similar time-line,[ii] but 65 years prior, within the first year of commercial usage, two Comet jetliners suffered hull losses as they failed to become airborne. After the second incident, this time with fatalities, pilots learned to change their behaviour to adopt to the new jet plane aerodynamics. In the second year of the Comet's operation, two more fatalities occurred, this time airborne, due to sudden explosive decompression (Great Britain. Ministry of Transport and Civil Aviation 1955; Withey 1997). It is this fourth accident that shaped engineering practice permanently and beyond the field of aviation. Engineers learned to avoid stress peaks in corners through ostensible small changes in design but with great mechanical implications leading to modifications in hardware design (Great Britain. Ministry of Transport and Civil Aviation 1955; Rosenberg 1982; Sharma 2017). Learning also occurred as a by-product to usage sans tragic incidents (cf. Sharma 2017). For example, with cumulative maintenance experience, personnel learned to significantly stretch service intervals (Rosenberg, Thompson, and Belsley 1978; Rosenberg 1982). This reduction in cost and increase in operating performance of the aircrafts was achieved by maintenance personnel's initial comprehension of unnecessarily dissembling and changing well-functioning parts, and the consequent introduction of new testing devices and practices (ibd.). Operating performance was furthermore improved by iterative stretching of the aircraft hull and wing profile modifications (ibd.).

The same underlying principle of performance stretch was applied to the proven predecessor Boeing 737 models to obtain an increase in carrying capacity/a decrease in costs per seat. For their latest version of the 737-8MAX, the focus was on improving performance by reducing operating costs, increasing carrying capacity, decreasing fuel consumption, and increasing range (Boeing Company 2020). This deemed mainly necessary newer engine versions differing in size and nacelles applied, shifting the planes centre of gravity and aerodynamics (ibd.). To avoid a changing flight behavior, which the pilots were used to in the predecessor models of the Boeing 737NG, Boeing decided to implement a flight control law that proved successful for their KC-46A Pegasus tanker, instead of re-modifying the aircrafts aerodynamics (ibd.). In detail, this Manoeuvring Characteristics Augmentation System (MCAS) flight control law was intended to provide consistent aircraft handling qualities and avoid potential decrease in safety margin in rare unusual flight conditions at elevated angles of attack by supporting the pilots' behaviour (ibd.). As often common in aviation accidents, atypical events bring to the surface multiple failures, which lead to fatalities. Such as in the Boeing 737-8MAX case, among others, that the manufacturer anticipated a different "natural" operating behavior in the rare event of a sensor failure of the MCAS system.

However, since the effects of learning by using weighed so heavily in the past for technological progress (Enos 1962; 2002; Rosenberg 1982; von Hippel 1976; Pisano, Bohmer, and Edmondson 2001; Sharma 2017) and, casting aside all the surfacing transparency issues that accompany the Boeing 737-8MAX crashes, one may ask why these incidents occurred, despite meticulous testing and serving customer needs in such close and prolonged manufacturer-operator interaction that the aviation industry has shown over centuries. A large body of research into learning by doing evidenced a non-linear connection between accumulated experience and progress in variables influencing operational performance, such as a decline in required direct labor input over an increase in output quantity and quality as an effect of accumulation of production experience (Wright 1936; Alchian 1963; David 1973; Lundberg 1961; Hirsch 1952; Arrow 1962; Levitt, List, and Syverson 2013; Pisano 1996; Pisano, Bohmer, and Edmondson 2001). Modelled into learning curves, the organisation's doing is shown to yield most progress in the early stages (Wright 1936; Arrow 1962) and to deviate across plants, kind of products and processes applied (Hirsch 1952; Asher 1956; Stobaugh and Townsend 1975), but also for manufacture similar in kind and scale (Alchian 1963; Pisano 1996; Levitt, List, and Syverson 2013; Pisano, Bohmer, and Edmondson 2001). Interestingly, as a by-product of productive activity, Lundberg (1961)[iii] evidenced for an extended period of time, 15 years, organizational productivity (output per man-hour) to increase at an annual average growth rate of 2% due to improvements in work force performance of operating fixed, unaltered facilities—better known as "Horndal effect." Endogenous to an organisation, doing may be different in locus of productive activity to using (Rosenberg 1982; Pisano 1996; von Hippel and Tyre 1996), yet the learning generated similar in locus, consequent to active problem solving (Thomke 1998; Sharma 2017). However, although productivity gains with doing are well identified, the ones of using established technologies lack consideration. Especially the sources motivating users' to problem-solving are yet to be understood.

In this paper, I investigate a potential reason for exogenous learning to occur despite meticulously addressed user needs due to prolonged operation, using data on the utilization of a commercially well established technology for subtractive machining principles. I conducted elaborate observations on a sample of both experts in and on the field of applying the technology and collected detailed data on manufacturer employees involved in learning-before-doing and after-doing as well as operators in 38 firms over the time period between 2011-2016.[iv] With parts of this unique dataset, I shall explore the gap between manufacturer anticipated product characteristics and perceived individual user/sense-experience that may yield performance improvement—thus, if both can interact in the same space of logical thought system. The following, second section, serves as an overview of the particular technology applied, for the reader unfamiliar with the technology of CNC laser machines and procedure studied. The third section presents the inductive study design to explore manufacturer intentions and raise latent user understanding. The fourth section comprises the findings of my ethnographic field observations and interviews. Concluding the paper, I discuss the theoretical and practical implications of my findings in light of further research in the search to understand, if both manufacturer and user act upon/ respond to a logically uniform language system.

Background: Producing with CNC Laser Machines

This study explores end-user operation of CNC laser machines to perform procedures, such as cutting and engraving, to yield commercial and industrial goods in a wide range of industries. For comparability of study data, I focused on those users applying four differing types, in size and power, of flying optics laser machines of one manufacturer but with (hardware and software) interfaces of same structure and underlying logic. Since the outcome of operators' interactions with this machinery play an important role in our every day lives, readers unfamiliar with this technology may find some contextual information useful.

CNC laser machines,[v] colloquially known as laser engravers, cutters or simply lasers, automate previously manually processed subtractive manufacturing procedures to achieve considerably faster and more accurate results. The technology expanded *potential applications*, with the matrix of process-able materials ranges on one spectrum from flexible to rigid substances and on the other one from low-porosity to of high-density objects. For instance, paper, rubber, leather, wood, glass, foam, plastics, and compounds, materials that were processed manually in the past, can now be exposed to the laser machines (Sharma 2017). Capable of individual, batch and serial production with this group of different material properties, the range of possible applications is numerous, leading to usage of the technology in a spectrum of industries, from commercial goods to tech. For example, CNC machines are standard equipment for firms in the industries of advertising, metalworking and industrial supply. Firms applying the machines of the manufacturer—whose usage I will examine—are equally active in the electronics, medical-technology and education industry. A globally common application in the generally widely dispersed advertisement industry is for instance a product familiar to, and probably even used by, the reader. Rubber stamp plates, the heart of every stamp, pick up ink and leave behind a lettering or logo mark on paper that adds meaning to the world of the applier and/or receiver. Simple and useful, stamps are still in use in our everyday world of communication. In professional letters, company stamps mark formality. Until this day—more than 300 years after first recorded implementation—postal markings record the place, date, and times of the mail order received and cancel the postal stamp to avoid its reuse. When travelling, crossing borders or in other official relations, government officials use stamps to record validity or add some sort of security to official documents. Another typical application is for instance the manufacture of plexi-glass signage such as exit-signs in public buildings or office door signs. These few examples, in only one industry, already highlight how widely spread this relatively unknown laser technology is and the productivity it added to firms and laborers, creating the products we take for granted on a daily basis.

The *role of operators* and user firms respectively, is to translate a customers' desired outcome—a theoretically intended potential—to correspond with a perceived real one—a future potential scenario into an actual one. This requires operators to understand customers' languages to be able to best transform a physical input into the desired perceived output. Operators should also command both the software and machine languages to translate the mental picture first into digital information that is typically a vector drawing reflecting the geometry and other information to be processed. They further manipulate this information corresponding to the software and machine logic. This convolute of information in the form of digital input to achieve the outcome is then, sent to a printer program, translated to be understandable for the machines to create the real physical product. Operators ideally grasp the language of the machines too so as to recognize how their input is converted. Thus, to match the customers' perceived actual outcome with an initially perceived desired one, users manage and command a serpentine of variables into various languages.

Operators' task before/pre-machining is to constrain these variables, provide processing input and parameters, monitor the machines advancement during/in-machining and rework the workpiece, clean service and maintain the laser after/post-machining. The sequence of the post-machining workflow is in general upon the user firms' preferences and entails the following steps. Users are required to place a physical input/the workpiece into the machine by positioning it on a working table that allows for the accurate referencing to (a zero point of) the machine's axis and software coordinates. The laser beam is focused onto the appropriate workpiece-height by either option of manual, semi-automatic or automatic focusing. For manual and semi-automatic focusing, machine input of moving the working table is required. An operating menu is located next to the machine's lid on the top panel's right hand side, it entails functions of starting and pausing machining, moving the cutter head horizontally and the working table vertically, operating the exhaust fan, sub-functions for quick access, and an emergency stop.

Furthermore, the application of two software programs is deemed necessary for pre-machining. They provide the interface for input and translation of work order information from user language to a language understandable to the machines to conduct a work order. A printer driver converts graphic data from vector software-programs to a printing job. A specific software application by the manufacturer allows setting/adjusting of machining parameters for the intended process and material. Three parameters need the operator's particular attention as they influence the material's exposure to the laser beam and the outcome significantly: cutter head velocity, laser power, and laser pulsation. Finally, machining is started through the software or the operating panel, depending on the sequence of pre-machining. The operators' task during-machining is dominated by monitoring the process through the machine cover and interfere if problems occur, i.e. inflammation of workpiece, errors in trajectory, etc. After machining is completed, the output is inspected and post-processed by machine or removed and if necessary post-processed in other forms. The working table is typically cleaned directly after machining, the machine and exhaust system on a daily basis, services and maintenance work that are more elaborate and require dissembling of machine parts, scheduled as per manufacturer guidelines.

Basically, what I have described here are three forms of information operators needed to translate into a language understandable to the machine logic in pre-, in-, and post-machining—physical, mental and manual input. The skills required for being capable to produce with CNC laser machines are generally relatively low and dependent on material processed, applications or aspired outcome quality. The mental-workload, however, is consequent to the amount of settings and interacting complexity of parameters. Machining individual items, non-feasible for standard procedures, demand the most advanced skill set, small-series and batch productions intermediate skill, and serial production or repetitive work with predefined parameters the least comprehensive versatility with the machines.

Study of Manufacturer's External Communication

Manufacturers' logic is at its large revealed by their "outward" communication as it expresses their intended perception of the technology, how they understood the demand in the market, and how to best supply to serve this unfulfilled need. All kind of information for users, such as the offered technologies, manuals, documents describing the *modus operandi* of the technology and any other documentation addressed to users or potential customers, served insight on the utilization understanding and record on convergence to user language. They were thus studied for this research, beyond serving to comprehend contextual field knowledge and complemented with non-structured narrative interviews. I conducted interviews and follow-up conversations with key research and development, field service and marketing employees, at the manufacturer's headquarters. The interviews provided information that informed and complemented the records of the company's understanding of utilization language and strategic adoption to a perceived market demand. The knowledge sharing as a function of assigned meaning and understanding across three occupational communities, influential for the inwards-to-outwards knowledge-transformation of the organisation was traced. User requirements and their alterations in context of user feedback to yield in process and product manifestation were discussed from the engineers' and service technicians' perspective. This in fact is important as "a large part of human communication takes place tacitly, through the absence of communication (and) is increasingly overlooked" (Watzlawick 2011, 131) and may also include technology. The shift of understanding of the technology to find a common outwards directed voice and "face" was raised with the firm's marketing employees.

Communication may be considered a two-way street of reciprocal action and reaction exchange. The receipt of information, such as a machine or software update, may evoke a backflow of user response. The delta in perceived provided solution by manufacturers and the actual remedy experienced by users, may be found in the communication of both sides. It is this backflow of information that is of interest to understand discrepancy in the manifestations of meaning between the provider of the solution and the user of it. Therefore, field information of the manufacturer's service technicians was collected and how this acquired knowledge was transformed in the manufacturer firm. This field documentation reflected the technicians' understanding of the users' active and passive communication back to the manufacturer through verbal dialogue and their issues encountered.

Study of Utilization

I aimed to understand the users' side of communication, by investigating their utilization logic with a newly conceived methodology. For these "ethnographic expert interviews" (Sharma 2017) I merged participant observations and narrative interviews with experts, in order to be able to raise the field-imposed determinants and latent contextual knowledge. I selected experts that had both expertise in working with the machines and on the field the technology is applied in. By doing so the research construed the experts to be the subject of observation but also to provide information on the general context of the industry and other users (cf. Meuser and Nagel 1991).

I selected the experts, by snowballing referral, with "expertise," "industry reputation of the user and/or her firm," and "field of application" as the main variables for the selection process. The starting point was a telephone outreach to firms that had a long-standing industry experience, reputation and/or a broad field of application according to the manufacturer's database. Over the course of several weeks 39 structured telephone interviews, with 15 variables to measure, were conducted and data of 114 operators and managers collected, resulting in 5 potential candidates that were interviewed face-to-face. Two of them were selected for the final ethnographic expert interviews as they were recommended as the most knowledgeable in and on the field but also exceeding all set requirements for the sample, such as covering the full range of production spectrum from special manufacturing to batch and mass production.

The selected male expert, 54 years old, worked in the industry for 40 years and for 12 years at a large European Copy Shop, Printing Services and Graphic Design franchisee in his most recent position, where he was training—for the entire company—new employees on this technology. He was additionally the point of access within the company with questions regarding utilization, but due to his industry reputation also for users—not only former colleagues—of competing firms. The other chosen expert, female and 39 years old, worked in the industry for 20 years and 2 years at a university lab for three dimensional model building and the head instructor, having guided far over 1,000 students working with the machinery at the time of my interviews.[vi] She was recommended in multiple telephone conversations due to the institute's sophisticated applications, such as, having helped a successful start-up with prototyping wooden bicycles or being able to even cut sheets of paper with the laser technology.

The qualitative inductive research structure was combined with my ethnographic participation in the users' working day and field-imposed-raising of informal open-ended questions. To holistically understand utilization behaviour, the questions were posed within the working context of the moment in order to trigger narratives of the operators' individual experiences and the problems other users in the field encounter. While participating for ten working days (8 to 13hours per day), I wrote up fieldnotes (when possible) in order to avoid laboratory interview conditions (cf. Laznek 1993; Diekmann 1995; Flick 2015). They represented narratives and observations of operation of a range of users—from first-timers to the experts—, of my own operating impressions, of cleaning and maintenance activities, of servicing by the manufacturer's field technicians and their interaction with operators. In total, interviewing material and contextual information of 2 experts and 24 users was compiled for the purpose of this study.

My analysis followed the general procedure of qualitative content analysis (Mayring 2000) with a general inductive emphasis. My open-ended gathered information in the field guided theoretical pre-considerations for extraction and structuring with deductive material being consulted only when deemed necessary or to collate conclusions drawn. Thereby, this data structuring was oriented on suggestion of open category manipulation to bridge the contradiction of theory guidance and openness of the qualitative content analysis (Gläser and Laudel 2010, 205). Transcribing, unitizing, coding, and categorizing lead to over 400 potential items to measure that could influence cumulative utilization experience. For the purpose of this paper only one of the findings, the deviating user from manufacturer logic, is discussed in the following.

Lost in Translation: Language Deviant Behavior[vii]

The manufacturer's field service personnel regularly conducted machine service and maintenance at user firms that lead to informal exchange of information between users and service personnel. Users informed the personnel about issues, which the latter would directly address with their knowledge and resources at hand. For resources not sufficient or available at that moment, personnel would consult back with their head office, to obtain required additional knowledge, tools, or other resources. In reverse, users got updated with information from the manufacturer. The investigated users and service personnel had established a good working relationship over the years and users would even call them on their mobile phones, in case they were "stuck" with a problem with the machine.

The service personnel transformed the information from a non-standardized user language to a structured and standardized manufacturer "language," making the information from different users comparable. This transformation of information however, was found to be a potentially critical variable when it comes to identifying the actual problems users face, especially the manufacturer's priorization of solving issues for the users. Information got lost in the conversion from "laborers' communication" to a common understanding within the manufacturer, with personal, emotional judgments being of influence. The service personnel would decide how to interpret information presented by users. In severity often found to be charged by their own assessment on how "problematic or dramatic" users are and what they considered to be relevant issues. Thus, only the user issues and needs that the individual service personnel considered relevant were reported to the R&D department as potential requirements for product and process alterations.

For instance, to stop the laser machines in case of "emergency," such as a potential machine crash of the laser cutting head with the work piece, users simply opened the machine cover, in order to stop the machine immediately, instead of reaching to the emergency stop button next to the operating panel. In observing the users post-processing their workpieces and their interaction with the service personnel and follow-up conversations with the latter, something interesting emerged. Several users complained that the laser sometimes randomly omitted engraving vector lines when stopping the machines. The service personnel however, could not identify the source of the problems and "blamed" the users' drawing files to be at fault, claiming the vector was not properly drawn by the user or his customer respectively, leading to such omitted engravings and cuts in the work pieces. Those user problems therefore, being considered of external source, self-caused and/or not important, were not recorded by the service personnel and reported back to the head office's R&D department.

During my ethnographic studies at the University, I observed such an incident of machine stopping. A laser machine instructor, cutting out pieces from wood, monitored the machine's working process through the transparent machine cover with his left hand placed under the cover's edge. Suddenly he opened the lid. The laser cutter had stopped immediately, a fraction before colliding with a dumbbell weight plate, which was positioned on the work piece. The instructor repositioned the weight plate and restarted the process afterwards. When I asked the user why he had a dumbbell weight plate in the machine and opened the lid to reposition it, he explained that he places weights on the wood-plate to avoid heat induced warping of the material, which would in turn lead to imprecision of the outcome. So he uses his dumbbell weights to fixate the wood vertically, impeding it to bend. Since the weights had to be placed strategically, often into the laser's processing path, he had to reposition the weights in order to avoid the laser going over or colliding with the weight plates. Which is why, given his positioning in front of the machine, monitoring the process through the machine's lid, he just opened the lid with both his right and left hand, instead of placing his right hand next to the menu panel, an uncomfortable position for him, in order to stop the machine when necessary. Observing the expert user interacting with a student, I noticed the expert's posture, while working at the machines, was similar to her colleague. She too was leaning towards the left, bending over the machine to look inside through the lid and had her left hand on the lid's handle, ready to open whenever she deemed necessary. After I asked why she would simply not "pause" the process on the menu panel she responded that, "pressing (the) pause (button) would not stop the machine immediately…" She added: "When it is urgent to stop the machine, this is not suitable, so I simply open the lid."

The manufacturer interviews revealed that the service personnel did not report the occurrence of the problem, of "omitted engraving lines," back to the headquarters. The manufacturer's R&D department was surprised that several users experienced this issue and none of the engineers could explain this matter. One engineer immediately left the room during the interview to test "stopping the machines" with their machines in the laboratory but could not find any issue. Involving the field force into the immediate discussion disclosed that they didn't consider it "necessary" to report this issue and led to the only explanation that users may have used faulty programmed software files. The head of R&D however, not content with the answers provided, ordered the field force—that had been informed about this matter by the users—to check these users' machines to find out what may be cause of this "mysterious" problem. Getting together three months later did not lead to further insights other than that the checked machines were found to be in proper working condition. In one instance, the service personnel even dissembled the machine's mechanics, but no issue could be found and the software and files seemed in proper order too. Testing the users' software files with the machines in the head office's laboratory and on different software versions did not turn out to be a fruitful avenue either.

To summarize the problem, in manufacturer's language "stopping" meant to cut the machine's entire power supply in case of an emergency such as a fire or any other safety hazard. For the observed users, "stopping" meant to only immediately stop the machine's working process, hence the movement of the laser's cutter head, when the stopping is initiated. This "user-language stopping" may approximate "pausing" the working process in manufacturer-language. This too however indicated different understandings, since the manufacturer did not understand pausing as a time sensitive matter to stopping the machine's cutter head, but let it finish the vector executed in the second the key impulse/signal was initiated. This did not comply with the users' way of working with direct machine control. It made the machine's response and working process respectively, indirect, as they were not under control to anticipate where exactly on the cutter head's (pre-programmed) path the laser would actually pause. By opening the lid, users could actively control the process, as the machine's safety brake would be activated and evoking an immediate machine response for what they understood to be "stopping the machine."

Empirical support for the differences in languages spoken between users and manufacturer is found throughout the data set. The manifestation of the manufacturer's logic, described in words with the operation manual that was not understood by users is further evidence for language deviant behavior. It showed both sides to speak fundamentally different languages and express them in different forms and words. To be understood as lengthy and written in "technical Jargon" by one user, illustrates the tension in concepts and languages between user and manufacturer. The same user however, described the manual to be generally simple in form: "Above all, there is a lot, yes, 'technical jargon. Ok, it's described in a pretty simplified way, but to be honest, I didn't really understand it" (User). Such contradiction, in this case, the user clearly expressed herself to be at fault, was found throughout the data-set. Users blamed themselves for the lack of understanding.

To bridge the difficulties this "static" form of communication evokes, among other suggestions, users found training directly from the manufacturer or an expert to be helpful in overcoming confusion. A common understanding may be reached more easily by explanations, leaving less room for individual interpretation. As a workaround to overcome confusion, users ran small experiments to figure out the effect of certain machine functions. The experiments shifted from random, in the early stage of learning, to being more deliberate with increasing experience. Fundamentally leading to a deeper understanding of the input-output translation, ultimately elaborate experiments were causal that users' perceived reality of the final product would match their intended theoretical outcome as close as possible under the given constraints. Thus, to attain sense in their working-world, the centre of which is, at least in parts, the manufacturer's machine, users intended to make sense of the manufacturer itself.

This general difficulty to bridge understandings was fuelled by diverging units to measure several working concepts. Users measured productivity with jobs achieved (according to the customers' requirements) in a given amount of time, whereas the manufacturer measured it with possible machining per second. While machine speed is certainly a critical factor for productivity in laboratory conditions, in real-world applications the effect of cutter head speed was found to be *inferior* in most cases. Operators "don't have the time" (Expert) for lengthy machine monitoring—often for hours—, as required per manufacturer protocol for safety purposes, needing to get as much work done as possible in a day. Leaving the machine unobserved however, was considered risky and evoked emotional stress—"we are afraid to leave it alone. . . yes, so if it starts to flame, we have a problem" (User). Therefore, users solved the problem with their own adjustments or different forms of disembodied or embodied workarounds. For instance, they adjusted their work by fulfilling tasks next to the machine, adapted their workplace around machine observability or implemented cameras. The concept of data management was a *superior* source affecting productivity in the real world, bringing to the surface a diverging logic between user and manufacturer. This, the structuring of jobs in the software's task list, allowed to recall old jobs in order to save time by working with templates of given working parameters. The manufacturer provided a listing in alphabetical order by job-number/name, whereas in the users' logic demanded jobs to be chronologically listed by customer- or job-name. To help search for a job, the manufacturer offered to either filter for kind of process or resolution of the job—again a technical parameter, DPI—while users understood this to be best done by filtering by task or particular incidents that helped them remember the job.

Fixating work pieces in the machine's coordinate system to allow for only intentional relative movements of the cutterhead, to solely describe the intended path on the workpiece, is another major productivity affecting source. Fixation, however, also reflected the concept of quality, as it would impact the accuracy of the outcome. The manufacturer addressed the concept of quality on a theoretical level, by reducing vibrations as part of an overall effort of improving the machines. In contrast, users provided practical understanding, counteracting residual strain and reducing the relative movement of the workpiece, to produce more accurate results. Depending on the user's level of experience and kind of workpiece, different degrees of workarounds were implemented. For instance, adhesives, magnets or heavy objects, such as dumbbells—as was shown in the aforementioned example—were applied to weigh down the workpiece. In more sophisticated cases, self-made devices were developed to keep the workpiece surface in a defined position. All efforts, again, were made based on economic considerations, depending on the customers' willingness to pay for the outcome.

Dozens of other examples, for differing logical concepts and their manifestations in units of measurements or actions, can be found in the data-set. They exemplify the different contexts of reality of the individuals involved. The theoretical perspective of mainly the manufacturer's engineers to arrange the world into numbers and their product experience from laboratory testing conditions, was confronted with the practice-oriented reality of users and their economic understanding of manoeuvring in a competitive landscape in order to achieve operative effectiveness.

Conclusions

This inductive research provides evidence that learning by using lays at the heart of continuous productivity gains, even with prolonged usage of an established technology. Beyond product ageing, and despite testing and customer research to best address user needs, an existing gap between actual to potential performance of users is shown. This deviance in potentiality finds a root cause in the discrepancy of languages spoken between users and manufacturer. With the manifestations in form of words, text, symbols, software, hardware, and actions, this paper shows language to transport underlying concepts that increasingly diverge between user and manufacturer the further down one goes. Thus, while the expressions on the surface may be the same on both sides, the underlying fundamental concept may deviate between them. While users and manufacturer have the same technology in common and both sides mutually share terms, they show *language deviant behavior*, consequent to the individuals' specific (working) context. The context in which perception takes place, the theoretical one of manufacturer with experience in laboratory conditions vs. the applied world of usage, provokes different understandings of the same vocabularies.

An important example of such vocabulary is "Productivity" that holds a large untapped potential for improvement. Manufacturer and user address two different layers, machine vs. process improvement, and scales, economic vs. mechanical, to measure outcome. To be noted is users' second order change of productivity by outsourcing tasks that do not require individual input. Certain processes however, may only be outsourced with difficulty, requiring operators' direct input of specific knowledge and experience at that time. This is comparable with other professions, such as in aviation, where take-off and landing are critical flight situations requiring the users' utmost attention and input during operation. Input per time unit for take-off is greater than the input per same time unit at altitude. A complex field of variables has to be navigated and the window of error, the possible correct combinations to choose within limited time, is small. In such situations, cofounding variables may lead to the operators' activities beyond the (learned) protocol, often acting subconsciously, on instinct, thus showing a gap between developers' and users' logic.

The findings highlight some important implications for both manufacturers and operators alike. Users' recognition of manifestations of the different languages and their lack of adjustment to diverging logical concepts can be bridged by supporting their intentions for a better understanding. That local understandings can be transformed within organizations is shown by Bechky (2003), whereas this paper suggests that language transformation across occupational communities may be possible. This can be done through a direct exchange between the manufacturers' employees, which hold knowledge of and are experts in development decisions, and the users. Meanwhile, users should be encouraged to raise their voices in the search for explanations. In a less interactive form, manufacturers' can promote users' experimentation efforts to bridge the gap of understanding in order to unlock the potentials of productivity and satisfaction at work.

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[i] This paper is drawn from Sharma (2017).

[ii] On October 26th, 1952, the first hull loss was sustained, as BOAC G-ALYZ Flight 115/030 failed to become airborne at Roma-Ciampino Airport (CIA/LIRA), Italy. On March 3rd 1953, a second hull loss occurred, when Canadian Pacific Airlines CF-CUN failed to become airborne at Karachi-Mauripur RAF Station (OPMR), Pakistan, suffering the first fatalities. In 1954, on January 10th, BOAC G-ALYP Flight 781 (3rd Comet built) from Roma-Ciampino Airport (CIA/LIRA), Italy, en route to London suffered explosive decompression at altitude, suspicion of an engine turbine fault. BOAC G-ALYY, Charter Flight SAA Flight 201, from Roma-Ciampino Airport (CIA/LIRA), Italy, en route Egypt was lost 33mins in flight. Recently, in 2018, October 29th, Lion Air Boeing 737-8MAX PK-LQP Flight JT610 from Jakarta-Soekarno-Hatta International Airport (CGK/WIII), Indonesia, en route Pangkal Pinang Airport (PGK/WIKK), Indonesia, crashed approximately 11mins into the flight. On March 10th, 2019, Ethiopian Airlines ET-AVJ Flight 302 on, from Addis Ababa-Bole Airport (ADD/HAAB), Ethiopia, en route Kenya crashed 6min into the flight (Federal Democratic Republic of Ethiopia Ministry of Transport 2020).

[iii] I referred to accounts of David (1973) and Arrow (1962) cf. Lundberg (1961), pp. 129-32.

[iv] The data were initially collected as part of a larger study on the user-friendliness of CNC laser machines of one manufacturer and the soci-techno-economical impact on a diverse work force.

[v] They use a contactless subtractive manufacturing procedure, of mainly cutting (complete material separation along vectors) and engraving (removal with limited depth according to the DPI of digital graphics) with laser beam, of approximately 100µm focal diameter on the workpiece surface, where the material generally vaporizes and is sucked in by an exhaust. Workpiece positioning relative to a reference point and constraining variables of freedom in all axes allows referencing the digital input, relative movement of the lens to the material, following any trajectory.

[vi] As per her own account, during the regular term on average 40 students are using the machines per day.

[vii] The findings presented in this section are quoted from Sharma (2020).

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