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SOCIAL MECHANISMS OF LEARNING AND TECHNOLOGY ADAPTATION IN THE POLISH STATE FIRE SERVICE

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Abstract: Contemporary technical systems, which are increasingly complex and automated, require a new perspective on the relationship between humans and technology in the context of human safety. At the core of these considerations is both the role of the human factor in safety and environmental management systems and the organizational aspects that connect technical, organizational, and human issues. Integrating these areas, fundamentally based on knowledge management, allows for the construction of safety systems that meet the requirements of a responsible approach to risk. The purpose of this article is to present the processes of creating new knowledge and the methods of experience transfer within selected organizational units of the State Fire Service (PSP) in specific provinces of Poland. The research, conducted from September 2022 to September 2025, consisted of an analysis of existing documents regarding the training of PSP officers and a qualitative sociological analysis, and focused on participant observation conducted during planned exercises, officer training and actual rescue operations involving the PSP. The primary goal of the observation was to monitor the process of introducing and practically utilizing the Staff Support System (SWS) software, a tool designed to aid staff operations during largescale rescue actions. The observation covered the officers' interaction with the system, the identification of methods for creating new system functionalities, and the methods of experience transfer regarding its operation among staff participants. The study was carried out in selected PSP organizational units to capture differences in the adaptation and utilization of this technology.
Keywords: knowledge management, sociology of knowledge, organizational sociology, participatory design, state fire service

1. INTRODUCTION

Contemporary organizations, particularly those responsible for public safety, are confronted with a dynamic threat environment determined by technological advancement and the intensification of climate phenomena. In the context of the State Fire Service (PSP), which is based on a well-established and highly standardized system of education and professional development, this poses a fundamental research problem. This problem lies in the insufficiency of traditional, replicative models of knowledge transfer in the face of new challenges. This generates the necessity to transform the formation into an

organization that actively learns and creates new operational knowledge. This paper undertakes an analysis of this issue, departing from the traditional, hierarchical model of innovation implementation in favour of a participatory approach.
The subject of the research is the process of bottom-up creation and implementation of technological innovation within the PSP structures, analysed using the case study of the Staff Support System (SWS). The study focuses particularly on the application of User-Centered Design (UCD) and Participatory Design (PD) methodologies as mechanisms for knowledge generation. A central element of the analysis is the identification and typology of the diverse attitudes and levels of engagement among the officers – the end-users – who actively participate in this process.
The main cognitive aim of the paper is to identify and characterize the key typologies of attitudes (including proactive-constructive, visionary, expert, active resistance, or precautionary) that emerge during the iterative software co-creation process and have a critical impact on its dynamics and final form. The utilitarian aim, in turn, is to demonstrate how a participatory implementation, carried out under the „created by firefighters for firefighters" model, allows for the effective overcoming of systemic competency gaps resulting, among other things, from the „universal rescuer" model.

2. METHODOLOGY OF RESEARCH

The adopted research methodology is embedded in the qualitative paradigm, which is the most adequate for achieving the cognitive aims focused on understanding complex social and organizational phenomena. The main research strategy was a case study, oriented towards an in-depth, holistic analysis of the implementation process of a technological innovation (the SWS system) within its natural operational context. This approach made it possible to capture the dynamics of the process and to identify user attitudes in real-world conditions.
The selection of the research sample was purposeful. The research covered the software implementation process within the PSP structures in two selected voivodeships. The selection criterion for the units was their active participation in the system's implementation and testing process, which guaranteed access to rich empirical data. The subjects of the study were PSP officers performing various functions (from operational officers, through dispatchers, to command staff), who had direct interaction with the system during exercises, training, and real operations.
The research material was collected between September 2022 and September 2025. Observations were conducted in a diverse operational environment, encompassing both field simulations and actual rescue operations, with the research process being non-invasive and causing no disruption to operational procedures. The procedure did not require the processing of personal data; stringent information security measures were implemented, limiting access to raw data exclusively to the principal investigator and storing it on secured digital media. The study group consisted of 100 officers representing rescue units and municipal/district headquarters across two voivodeships.
Drawing upon the methodological paradigm outlined by Babbie (2002), the observation was oriented towards achieving both descriptive and explanatory objectives. In accordance with this approach, the aim was not only the meticulous observation and description of human-technology interaction processes (description) but also the understanding of the underlying causes of the observed behavioral patterns (explanation). In this context, the detailed evaluation focused on technical and cognitive parameters,

such as interface ergonomics and clarity, application responsiveness, and the accuracy of data interpretation. The explanatory dimension of the study, meanwhile, concentrated on identifying the determinants of bottom-up initiatives regarding the proposal of system enhancements.
Methodological triangulation was used in the data collection process, combining two main research techniques. The first, fundamental research instrument was participant observation. The second key research instrument was the analysis of existing data (desk research), which included document content analysis. A division into two categories of sources was applied here. The first consisted of formal legal regulations (acts and ordinances) defining the operational framework of the PSP and the National Firefighting and Rescue System (KSRG). The second category, crucial from a procedural perspective, consisted of internal PSP documents.
The research procedure involved the systematic collection of data from both sources throughout the duration of the implementation process. The result of this analysis is the typology of attitudes presented in this paper. Data derived from the document analysis, on the other hand, served as the interpretative context, allowing the observed attitudes and phenomena to be embedded within the formal procedural and legal frameworks in force within the organization.

3. RESULTS

The analysis of existing documents allows to conclude that two acts, both passed on August 24, 1991, are of key importance to the operations of the State Fire Service (PSP). The first of these is the Act on the State Fire Service. It constitutes the basic act regulating the status of the formation itself, defining it as *professional, uniformed, and specially equipped formation, designated to fight fires, natural disasters, and other local threats* (PSP Act, 1991 Art. 1(1)). The second pillar is the Act on Fire Protection, which has a broader scope and concerns the entire fire protection system in the country. It specifies the general goals and principles of this protection, including threat prevention and ensuring forces and resources to combat them. Most importantly from the perspective of the PSP's operations, it is this act that establishes and defines the KSRG (Act on Fire Protection, 1991, Art. 14.). The State Fire Service constitutes the core and heart of this system, coordinating its activities in its area. This entire legal system is supplemented by numerous executive regulations, issued mainly by the Minister of Interior and Administration. These lower-ranking acts detail the provisions of the laws, specifying, for example, standards for uniforms and equipment, detailed rules for conducting rescue operations, service regulations, OSH (Occupational Safety and Health) norms, or principles for training officers. The latter form the foundation upon which PSP officers build the knowledge and skills necessary in their daily service. The latest edition of the **„**Principles of Organizing Professional Development in the State Fire Service**”** (KG PSP, 2024) synthesizes the key assumptions and structure of the professional development system in the PSP, in accordance with new rules approved by the Chief Commandant of the PSP. This document, developed based on an evaluation of the 2016 regulations, introduces a comprehensive and structured model for the continuous development of competencies for all firefighters and civilian employees of the formation.
The main assumptions of the system are based on four pillars:

- Professional development is an obligatory, continuous process carried out throughout the entire period of professional activity. This is a key element of

investing in human capital, affecting the formation's effectiveness and its social image.

- The system operates in an annual calendar cycle, which includes four stages: diagnosis of training needs, development of plans, implementation of activities, and verification and summary. This approach guarantees that actions are based on reliable analysis and real needs.
- The principles precisely differentiate the organization and forms of development depending on the specific nature of the service and the position held. Separate paths are provided for firefighters serving in the shift system (in firefighter and rescue units and at command posts) and for people in the daily service schedule and civilian employees (including command staff, specialists, and didactic personnel).
- The document clearly defines responsibility for the formation, implementation, and supervision of professional development at all levels of the PSP structure – from the district/city command, through the voivodeship, up to the National Headquarters and PSP schools. The process is carefully documented, which enables effective verification and completion of the annual cycle.

The training system in the State Fire Service (PSP) is a multi-stage, hierarchical, and precisely legally regulated process, the aim of which is to prepare officers to perform service in various positions and to ensure the continuous raising of professional qualifications. This structure can be divided into two main streams: education, which leads to acquiring qualifications in a given corps, and specialist and development training.

The basis for building a career in the PSP is education, closely linked to acquiring subsequent corps: privates, non-commissioned officers (NCOs), aspirants, and officers. The first, mandatory stage for every newly admitted officer is basic training in the firefighter profession. It concludes with an exam and the granting of basic qualifications, which allows for appointment to the rank of private in the PSP. The next level is NCO education, in fact carried out after basic qualifications, which grants qualifications to hold positions in the NCO corps. A higher level is aspirant education, conducted in one of the PSP Aspirant Schools. Graduates obtain the professional title of Fire Service Technician and qualifications to hold positions in the aspirant corps, performing specialist or lower-level command functions. The highest level is officer education, carried out at the Fire Academy in Warsaw. From the 2025/26 academic year, it includes uniform master's studies for firefighters in candidate service (concluding with the title of Master of Science in Fire Safety Engineering and the granting of the first officer rank). In previous years, it included first-cycle studies (B.Eng.) culminating in the title of Engineer of Fire Safety and the granting of the first officer rank, as well as second-cycle (M.Sc.) studies. Postgraduate studies are also offered, intended mainly for officers with civilian higher education, as well as extramural studies for officers in service who wish to obtain officer qualifications (KG PSP, 2020).

The second stream is specialist and development training, which applies to all firefighters, regardless of their corps. Their purpose is to gain or maintain specialist qualifications. Examples of such training include the mandatory and regularly recertified (every three years) Qualified First Aid (KPP), as well as courses in technical, chemical, water-diving, or height rescue, and command training for various levels of management.

The presented, multi-stage, and strictly legally regulated system of education and training forms the foundation of the PSP's professionalism. It ensures a high level of

standardization and the effective implementation of officers for rescue tasks within the framework of applicable procedures and using available equipment. It is a system focused on the effective transfer and consolidation of existing, verified knowledge and practical skills, which is key to ensuring the repeatability and safety of operations. Using an analogy, rescue operations can be compared to designing concrete beams. Every minor error by the designer can end in tragedy and enormous losses. The selection of appropriate materials, geometry, adaptation to the terrain is crucial at the design stage (Michałowska-Maziejuk et al., 2024). Failure to adhere to proven procedures and established knowledge during either design or rescue operations may result in irreversible consequences.

However, in the face of a dynamically changing threat environment-determined by technological progress (challenges related to electric car fires), energy transition (photovoltaic power supply), or the intensification of climate phenomena (frequent flash floods or floods) – relying solely on established knowledge and procedures is becoming insufficient. Modern rescue requires continuous adaptation and the proactive pursuit of new solutions. For this reason, the PSP must function not only as an organization that replicates competencies but also as an organization that learns and actively creates new knowledge.

In the traditional model of innovation implementation in hierarchical organizations, knowledge is often perceived as an external product that must be acquired (by purchasing a finished product) and then transferred to personnel through training. It should be remembered that the effectiveness of advanced technologies in security systems is inextricably linked to the competencies of the personnel. For this reason, a new, participatory method of knowledge creation is emerging, which reverses this process: instead of training people to use a tool, they are involved in the process of creating a tool that is ideally suited to their competencies and operational realities. An excellent example of this approach is the process of building and implementing the SWS –Staff Support System (Skorek, 2024). This innovation did not arise from a central directive but as a bottom-up initiative born from direct operational observation. A PSP officer, noticing the inefficiency of manual procedures at the forces and resources reception point during exercises in Kuźnia Raciborska, identified what Drucker defined as an incongruity (Drucker, 2006) – a discrepancy between the actual state and the desired state. The need for rapid and efficient management of operational awareness is analogous to challenges in industry, where the need to reduce costs and improve efficiency leads to the implementation of advanced systems. Industry, by developing cloud reporting, significantly reduces waiting time for product status information and allows for immediate data access (Cieśla and Ulewicz, 2024), which aligns with the need for immediate support for the command staff during rescue operations.

The use of the User-Centered Design (UCD) and Participatory Design (PD) approaches was key. UCD is defined as a methodology and design philosophy that postulates the prioritization of the needs, goals, and success metrics of the end-user throughout the entire product development process; it is indicated that success is measured by the ease with which users internalize the system's operation, the efficiency of task completion, and the overall level of satisfaction with the interaction (Lanter and Essinger, 2017). The genesis of this concept dates back to the 1980s and is associated with the work of Donald Norman's research laboratory at the University of California, San Diego, and its detailed development was presented in 2004 (Abras et al., 2004). The publication indicates that

UCD encompasses a spectrum of diverse approaches in which the degree of user influence on the final shape of the project varies; it can range from consultation during the requirements gathering and validation through usability testing, to a model of deep partnership throughout the entire design cycle.
PD is defined as a heterogeneous set of principles and practices aimed at increasing the responsiveness of technology, tools, environments, and social institutions to human needs. This goal is achieved through the direct involvement of people in the co-design process of the systems they are the intended users of (Robertson et al., 2010). At the core of this approach lies the fundamental assumption that the active shaping of the social, technological, and material environment by the users themselves leads to its better adaptation to the realities of their daily practices and specific requirements (Jacucci and Kensing, 2006). From the perspective of the learning sciences, participatory design is also perceived as a form of learning that builds „scaffolding" for the design experience. This process stimulates participants' reflexivity on their own knowledge and facilitates the integration of their previous experiences, which shows close links to theories of metacognition and learning (DiSalvo, 2016). Involving firefighter users in the design process is a practical implementation of the digital responsibility principle, which aims to adequately address the concerns of clients and employees and ensure the required digital competencies (Suchacka, 2020). Moreover these models facilitate the contextualization of the user within their authentic social milieu while prioritizing their specific requirements. Concurrently, they ensure user involvement in the creative process is both deliberate and moderated, thereby neutralizing hierarchical imbalances and enhancing inter-group communication. Furthermore, the integration of sociological constructs-such as social roles, group affiliation, and cultural capital-enriches the design methodology by providing unique analytical frameworks.

Table 1
Comparison of UCD and PD models

Case	User-Centered Design (UCD)	Participatory Design (PD)
Role of the designer	Designer as a mentor, diagnoses and prescribes the solution.	Designer as a coach, helps the user develop the solution themselves.
Role of the user	Source of information, tester, subject of research.	Partner, co-creator, active team member.
Main goal	Usability, empathy, fitting the product to the needs.	Usability and democratization of the process and empowerment of users.
Key methods	Observation, interviews, usability tests.	Joint workshops, prototyping with users, role-playing, brainstorming.

Source: Own study based on mentioned literature.

Instead of working on the product in isolation, the team adopted an iterative experimental model, using exercises as a research training ground. This knowledge creation process included the acceptance of failure as a natural stage of development. Initial failures made it clear that communication was key, as was transforming users from passive testers into active co-creators. In subsequent stages, by changing the approach and involving officers from different units in the process, the application was dynamically adapted to their real needs.

Such a participatory deployment of SWS, where the active involvement of officers in the software creation process led to the development of genuinely useful functions, directly addresses one of the main challenges of the PSP, the „universal rescuer" model. This model can hinder the development of deep specialized competencies, for example, in IT. The SWS implementation showed, however, that instead of requiring rescuers to learn complex systems from scratch, a tool built „by firefighters for firefighters" could be created. Such a system is intuitive and tailored to operational needs.

Systemic counteraction to competency gaps, resulting from rapid technological development or breaks in equipment use, was carried out in subsequent stages. The SWS implementation was combined with cyclical training sessions involving an internal trainer and a representative of the supplier (in this case, the original development team). This hybrid model-combining bottom-up, participatory knowledge creation with its subsequent systematic, cyclical reinforcement – ensures not just a one-time training but, above all, the systematic refreshing of skills. Thanks to this, despite the universal nature of the service, it became possible to achieve and maintain the necessary level of proficiency in operating the key software, which directly translates into its effective use during rescue operations. An important element of the system's validation was its operation under real operational conditions, related to a direct threat to life or property. This allowed for the assessment of its functionality in the context of a fundamental change in operational priorities, which in crisis situations differ significantly from the assumptions adopted in exercise scenarios.

The deployment phase, which simultaneously constituted the next stage of functionality creation, provides a unique opportunity to conduct in-depth observations and analysis of the varied degrees of user engagement. Engagement (or lack thereof) on the part of the officers is not a uniform phenomenon. A thorough analysis of interactions within the project teams allows for the identification of several key, repetitive typologies of attitudes that have a direct, critical impact on the work dynamics and the final shape and reception of the product.

First, a broad group of users demonstrating high initiative was identified. It was observed that a significant portion of officers voluntarily and actively sought to make a substantive contribution to the development of the software's functionality. This initiative manifested itself through the formulation of constructive suggestions regarding process optimization, interface ergonomics, or the implementation of new modules desired from an operational perspective. It is worth noting that this group did not expect to be credited as software creators. Observation of this proactive group, however, made it possible to identify two different, dichotomous tendencies, conditioned by their reaction to the decision-making process related to their ideas:

- The proactive-constructive attitude (steadfast): This included users who demonstrated significant resilience to the lack of direct implementation of their suggestions. These officers, despite the lack of acceptance for some of their concepts, showed no drop in engagement and continued to actively participate in the development process. This attitude seems to indicate a deeper understanding of the complexity of the development process (like technical limitations or feature prioritization) and a motivation focused on the success of the entire implementation rather than on personal validation of their own ideas.
- The proactive-reactive attitude (offended): In this subgroup, a clear correlation was observed between the level of acceptance of their ideas and their continued

engagement. When the ideas proposed by a given individual were not reflected in the final version of the product, a distinct, noticeable reduction in motivation occurred. In extreme cases, this led to withdrawal from active participation and the adoption of a passive or indifferent attitude towards the project's further development.

Beyond the aforementioned dichotomy, the analysis of user behavior allowed for the categorization of several other distinct active attitudes:

- The strategic attitude (visionary): Individuals were identified whose activity extended beyond the immediate improvements to their own workstation. These users demonstrated systems thinking, analysing the impact of proposed changes on other organizational units and the overall operational strategy. Their suggestions often concerned redefining the approach to the problem, not just the software's functions. Drawing on Rogers' model (Rogers, 2003), they can be compared to „Opinion Leaders", as they also played an informal role of „change ambassadors", explaining the rationale for the implementation within their home teams and building a positive reception for the system.
- The specialist attitude (expert): This is an attitude characteristic of users with deep but narrowly focused domain knowledge. Their contribution to the project is invaluable for ensuring the correctness of operational logic in a specific area. However, this engagement is strongly concentrated on their own scope of duties, with little interest in ancillary modules. They show a tendency to highly prioritize functionalities that are key from their perspective, sometimes at the expense of the broader system view.
- The active resistance attitude (damper): It should be noted that active participation did not always have a positive vector. Individuals were observed who engaged in the process (like participating in tests or meetings) mainly to prove the dysfunctionality or pointlessness of the implemented system. This attitude manifested itself through destructive criticism, idealizing previous (often manual) solutions, and pointing out numerous flaws without simultaneously formulating constructive proposals for their resolution or ignoring proposed workarounds.
- The novelty-oriented attitude (enthusiast): A specific group consisted of users for whom the main motivation was a fascination with the technology itself and its innovativeness. They showed a high readiness to test new functionalities. Their suggestions were sometimes creative but carried the risk of being detached from real operational needs and promoting solutions that were impressive but not necessarily effective.
- The precautionary attitude (technophobe): In contrast to the resistance attitude, this activity is motivated not by ill will, but by a fear of change, loss of control, or a reduction in one's own competencies in the face of a new tool. This activity involved constant questioning about basic functions, raising concerns about the system's excessive complexity, and seeking confirmation that previous methods were safer or simpler.
- The opportunistic attitude (narcissist): Attitudes were also identified in which the declared engagement in the process seemed motivated by non-project-related factors. This activity could serve to increase visibility within the organization, build one's own position in the eyes of superiors, or treat project work as a desirable alternative to daily duties. The substantive contribution of such individuals was often superficial and subordinated to the current interpersonal dynamics in the team rather than a merits-based assessment of the solutions.

- The Immediate-Result-Oriented attitude (kettle): During the work, a group of users was also observed in whom high substantive engagement correlated with a low tolerance for the timeframes of the creation process. This attitude was characterized by clear frustration during the transitional period – from the moment a need was reported or a concept accepted to the delivery of a fully functional module. This period was perceived by them not as a necessary creation stage, but as an unjustified delay. The escalation of irritation occurred particularly when a new function was already partially visible but not yet fully operational or contained errors.

4. CONCLUSION

The analysis, conducted based on the case study of the SWS implementation in the PSP and confronted with the subject literature on knowledge management and design methodologies, allows for the formulation of several key conclusions.

First, the research confirms the thesis that the traditional, hierarchical model of knowledge transfer, based on a structured system of training and the replication of procedures, is insufficient in the face of a dynamically evolving threat environment. Challenges such as electric vehicle fires or the effects of climate change require organizations not only to replicate but to actively create new operational knowledge.

Second, the study demonstrated that a bottom-up, participatory approach to innovation creation provides a highly effective response to this problem. Instead of acquiring external technology and training personnel to operate it, involving end-users in its creation process inverts this model. The result is a tool that is ideally suited to operational realities and existing competencies. This approach directly addresses one of the PSP's challenges, namely the „universal rescuer" model, which can hinder the development of deep specializations, like in IT. A system created in a participatory manner is intuitive for the target user, which minimizes the entry barrier and the competency gap.

Third, the success of participatory implementation is not automatic. It is critically dependent on understanding and actively managing the diverse social attitudes of the participating officers. The study allowed for the identification and categorization of nine key attitude typologies, ranging from the highly desirable to the problematic. Merely inviting users to co-create is insufficient; this process requires conscious facilitation, capable of channelling the energy of enthusiasts, managing the frustration of the impatient, and neutralizing the resistance of sceptics.

Fourth, the final validation of the system under real operational conditions, involving a direct threat to life and property, confirmed its functionality. This usability was proven in crisis conditions, where operational priorities fundamentally deviate from those assumed in training scenarios.

The study indicates that the optimal model for a hierarchical organization, such as the PSP, appears to be a hybrid model. It combines the bottom-up, participatory creation of knowledge and innovation (as in the SWS case) with the subsequent, systematic, and cyclical process of its reinforcement (through training with internal trainers). Such a combination ensures not only the creation of an adequate tool but also its long-term, effective maintenance within the organization.

As a qualitative case study limited to selected units in two voivodeships, this research does not permit direct statistical generalization of the findings, and its focus on a specific tool (SWS) may not fully capture the dynamics of implementing other technology classes within the uniformed services environment. Consequently, a pivotal direction for future

research should be the quantitative verification of the identified attitude typologies on a representative, nationwide sample of officers, which would enable a precise estimation of the actual prevalence of phenomena such as proactive-constructive or precautionary attitudes within the formation's structures. Furthermore, a valuable expansion of the research scope would involve conducting comparative analyses across other hierarchical security organizations, as well as longitudinal studies aimed at assessing the sustainability of the participatory model and user engagement over a longer temporal perspective.

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