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EXPERT TEAM DECISION-MAKING AND PROBLEM SOLVING: DEVELOPMENT AND LEARNING

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ABSTRACT

Traditional research of decision-making has not significantly contributed towards better understanding of professional judgment and decisions in practice. Researchers dealing with decision-making in various professions and natural settings initiated new perspectives called naturalistic, which put the expert in the focus of research and the expertise thus entered the core of decision-making research in natural situations.

Expert team is more than a group of experts. It is defined as a group of interdependent team members with a high level of task related expertise and the mastering of team processes.

There have been several advances in understanding of expertise and the team. By combining theories, models, and empirical evidence we are trying to explain effectiveness and adaptation of expert teams in problem-solving and decision-making in complex and dynamic situations.

A considerable research has been devoted to finding out what are the characteristics of experts and expert teams during their optimal functioning. These characteristics are discussed as input, process and output factors. As input variables the cognitive, social-affective, and motivational characteristics are presented. Process variables encompass individual and team learning, problem solving and decision-making as presented in Kolb's cycle of learning, in deeper structures of dialogue and discussion, and in phenomena of collaboration, alignment, and distributed cognition. Outcome variables deal with task performance – activities.

KEY WORDS

decision-making, paradigm, expert team, learning, adaptation

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INTRODUCTION

Experts, expertise and expert decision-making have been the subject of numerous interdisciplinary studies, often focused on particular professional areas. Several research approaches were initiated, ranging from philosophical, psychological, and computational to most recent in neurosciences. As traditional empirical studies were not able to explain professional decision-making in practice qualitative methods have been applied in the research of decision-making in natural settings. Models explaining the complex field of expert decision-making were being developed.

There have been several advances in understanding of expertise and the team. By combining theories, models, and empirical evidence we are trying to explain effectiveness and adaptation of expert teams in problem-solving and decision-making in complex and dynamic situations.

PARADIGMS OF DECISION-MAKING

Traditional research of decision-making has not significantly contributed towards better understanding of professional judgment and decisions in practice. This led researchers to challenge the prevailing, normative, classical paradigm, called *judgment and decision-making*, with its numerous models and approaches [1]. Researchers dealing with decision-making in various professions and natural settings initiated new perspectives called *naturalistic*, which put the expert in the focus of research and the expertise thus entered the core of decision-making research in natural situations.

Cohen [2] provided a framework for the discussion of three basic paradigm of decision-making process: the *formal-empiricist* paradigm (also known as classic decision-making), the *rationalist* paradigm, and the *naturalistic* paradigm (Table 1). The goal of the rationalist paradigm was to make the research more oriented towards cognition, while the naturalist paradigm placed the expert in the natural environment with his/her cognitive and affective processes at the center of the research focus.

Table 1. Decision-making paradigms.

FORMAL-EMPIRICIST PARADIGM	RATIONALIST PARADIGM	NATURALISTIC PARADIGM
normative (prescriptive) models of rational behavior	normative models	context-bound informal modeling
formal, context-free and abstract models, free of decision-makers cognition	retaining evaluation standards of decision quality	construction of descriptive models of proficient decision makers in natural contexts
discrepancies in performance are the fault of the model	discrepancies in performance are the fault of the decision maker, not of the model	
input-output orientation	orientation on cognitive processes and their limitations	orientation on processes and contexts: focus on experts' cognitive processes and naturalistic contexts
comprehensive information search		situation-action matching decision rules

choosing among concurrently available alternatives		mental simulation

Nearly all early quantitative models of decision-making in psychology and cognitive science were based on static theories, according to which the decision maker is supposed to choose the alternative with the highest expected *utility function*, while no explicit psychological dynamics is being taken into account.

Towsend and Busemeyer [3] developed the *Decision Field Theory* (DFT), a dynamic and stochastic framework for modeling decision-making, which takes into account the psychological processes involved in decision-making. DFT is based on learning and motivation theories, information processing theories, and theory on human decision-making.

Naturalistic decision-making paradigm (perspective) includes a number of theories and models about the functioning of expertise. For instance, Endsley [4] developed a model of *situation awareness in dynamic decision-making*. According to Endsley [5], effective decision-making depends on high levels of situation awareness, which involves three levels (perception, comprehension, and prediction) and mechanisms for selecting goals and action.

In addition to environmental or external factors (system capability, interface design, stress and workload, complexity, and automation), the model involves many individual factors determining how well people are able to develop good situation awareness (perceptual processing and limited attention, limited working memory, goal-driven and data-driven processing, expectations, pattern-matching schemata, and the use of mental models).

FACTORS OF EXPERT TEAMS DECISION-MAKING AND LEARNING

Expert team is more than a group of experts. It is defined as a group of interdependent team members with a high level of task related expertise and the mastering of team processes.

A team member must acquire task-related work skills for task performance and teamwork skills to function effectively as part of an interdependent team [6]. Consequently, it is not sufficient for the creation of expert teams that their members are task specialists or technical experts; they must also be experts in social relations and interactions that lead to adaptive coordinated actions (i.e. teamwork) within the context of technical expertise (i.e. team task) [7].

There have been several advances in understanding of expertise and team. By combining theories, models, and empirical evidence we are trying to explain effectiveness and adaptation of expert teams in problem-solving and decision-making in complex and dynamic situations.

A considerable research has been devoted to finding out what are the characteristics of experts and expert teams during their optimal functioning. These characteristics are briefly discussed as input, process and output factors as shown on Table 2.

Table 2. Feedback loop from outcome to input factors – variables.

INPUT VARIABLES	PROCESS VARIABLES	OUTCOME VARIABLES
individual and team characteristics: cognitive, social-affective, motivational	individual and team learning, problem solving and decision-making	task performance - activities
**	**	**
knowledge: declarative, procedural, strategic, tacit	collaboration, coordination	fluent and high level performance

metacognitive awareness	alignment	adaptation
mental model	adaptation	innovation
shared cognition	knowledge building	efficiency
distributed cognition	emergent understanding	better decisions
transactive memory	negotiation of shared meaning	
adaptive expertise	discourse: dialog, discussion	
beliefs, attitudes		
self-efficacy, self-regulation		

EXPERT TEAMS – COGNITIVE AND CONATIVE CHARACTERISTICS

Experts and expert teams must possess good team situational awareness, declarative, procedural, and *tacit knowledge* necessary for functioning in complex environments. This knowledge is referred to as *domain specific* knowledge. Like procedural knowledge, tacit knowledge is action-oriented, gained from experience, applied unconsciously, and is often difficult to verbalize [8]. Tacit knowledge underlies a wide range of expert skills. Wagner and Sternberg [9] noted two ways for enhancing tacit knowledge: (1) by making it explicit and sharing it; (2) by learning from experience. Tacit knowledge acquisition can be facilitated with reflection on one's experience and action (see Kolb's learning cycle and team learning).

According to Wenger [10], teams can learn and develop a special kind of memory, named *transactive memory*, which is a coordinated and distributed storage of knowledge. This kind of memory is the "property of a group". Is seems to be differentiated when group members possess different domains of expertise and there are incentives to remember different kinds of information [11]. Such situations occur in interdisciplinary expert teams.

Expert teams seem to hold *shared mental models* of the task, their teammates, situation and equipment [12]. These compatible mental models allow them to communicate and coordinate actions without explicit communication. Team members are able to interpret situations in a similar manner, make compatible decisions, and take coherent actions [13]. Expert teams are building also other kinds of shared cognition, e.g. *team metacognition* and *common ground*. With *shared vision* they build a sense of commitment on the base of their values and goals. Shared cognition is a necessary precursor to effective team processes as it forms the foundation for decision-making and problem solving.

Beside knowledge and skills, expertise involves also *self-regulatory competence* and perception of *self-efficacy*. Self-regulation is defined as self-generated thoughts, feelings, and actions that are strategically planned and adapted to the attainment of personal goals [14]. Expertise involves self-regulating of three personal components: one's covert cognitive and affective processes; behavioral performance; and environmental settings. Self-regulatory processes can help a person to more effectively acquire knowledge and skills and to develop perception of self-efficacy – a belief in his/her capacity to perform effectively [15]. This construct can be understood also on group or team levels. Thus, collective efficacy is a sense of a collective competence, shared among individuals in a team [16].

Expert teams need to possess also *adaptive expertise*, which is a special kind of expert knowledge. It helps an expert to know when, why, and how various aspects of his/her vast repertoire of knowledge and skills are relevant in particular situations. Schwartz et al. [17]

have proposed that the concept of adaptive expertise involves two dimensions: (1) processes that lead to innovation (invention); (2) processes that lead to efficiency through well practiced routines. The development of adaptive expertise helps expert teams to continually adapt to changes in dynamic environments. A *metacognitive awareness* has an important role in the development of adaptive expertise. Thus, to increase adaptive expertise, learning environments should include activities rich with reflection and metacognition, as is the case in team learning (see Kolb's learning cycle).

EXPERT TEAM PROCESSES

The collaborative team members need to be able to build an effective group process. The quality of the team's work depends on the group process, sharing knowledge with one another, understanding one another, elaborating one another's ideas, engaging in critical discussions, etc.

In recent decades, the cognitive complexity and demanding nature of issues dealt with in modern societies has increased, the problems are often ambiguous, unstructured and ill-defined, causing a need for flexible and *adaptable problem solving strategies* and frameworks by expert teams (composed of professionals from multiple subject fields).

One possible answer to such complex issues could be the development of interdisciplinary collaboration work culture and teams of varied experts from different disciplines combining perspectives of various fields. They should be able to perceive highly specific aspects of a problem that might be overlooked from a vantage point of a single perspective.

Collaborative or team learning puts into practice major conclusions from advanced cognitive theories, research and methodologies. A social constructivistic perspective is applied to collaborative learning by focusing on the group process, without excluding individual processes, with a particular reference to how the processes of cognition and communication can be conceived as situated, dialogic, distributed and emergent.

Understanding collaborative or team learning requires making sense of the conversation the participants engage in and the tools that mediate their learning [18]. Group thinking and reasoning are reflected in a collaborative discourse which provides evidence of interaction and semiotic structures (structure of information) that are being generated and used in an activity.

Decision-making and Kolb's cycle of learning

Decision-making can be presented [19] as a special case of Kolb's learning model which represents one of the fundamentals of our understanding and explaining human learning behavior. According to Kolb, the 'cycle of learning' is a central principle of his experiential learning theory, in which the learner follows a repeating sequence of *experiencing, reflecting, thinking,* and *acting*.

Decision-making in simple situations usually does not require profound or prolonged reflecting, so the decision-making process can be represented in a *single-loop reflection* cycle consisting of: *observing, reflecting, deciding* and *doing* (left cycle in the Figure 1).

Reflecting on the implications of our observations, drawing conclusion from them, and preparing and planning for decision process usually requires more profound processes of questioning and *reconsidering* our basic assumptions and conclusions, exploring and articulating new ideas and possibilities (*reframing*), considering new possible approaches and perspectives (*reconnecting*). *Double-loop reflection* cycle contains these component processes and contributes through more thorough deliberations towards better functioning of the primary (single-loop) cycle.

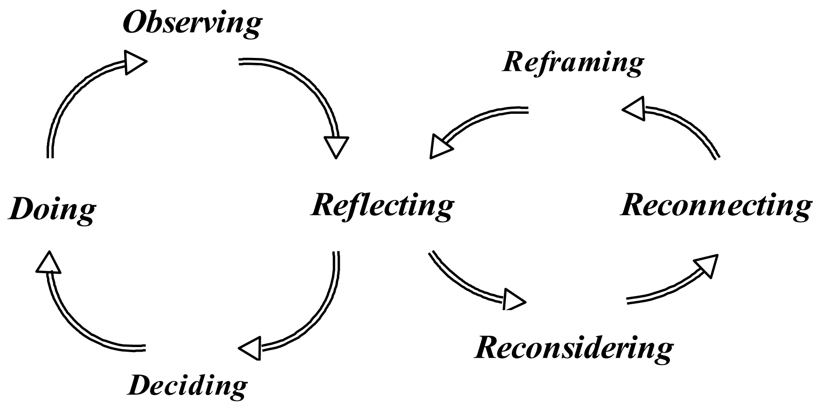

Figure 1. Learning wheel – single and double-loop cycle (adapted from [19]).

Another variant of Kolb's cycle is represented [20] with a slightly altered 'wheel of learning' of an individual (the inner wheel in the Figure 2). It dispenses with the *observation* component (before *reflecting* in the Figure 1) and introduces *connecting* (after *reflecting* – a postmortem about a previous *doing*) as a preparatory phase for *deciding*. During this *connecting* phase, which actually corresponds to *reconnecting* in a *double-loop reflection* cycle in the Figure 1, one creates new ideas and possibilities, generates hypotheses, and obtains new insights.

This 'learning wheel' is also suitable for representing a transition from an individual to a team as shown by the outer wheel in the Figure 2. Phases in the inner wheel (individual's) have equivalents in the outer wheel (team's): *reflecting* ↔ *public reflection, connecting* ↔ *shared meaning, deciding* ↔ *joint planning, doing* ↔ *coordinated action*.

Public reflection: The silent reflecting stage of an individual turns into a public one as members of the team discuss their assumptions, beliefs, convictions, etc., and engage in interactive and iterative processes of open communication.

Shared meaning: Eventually, the team is able to arrive to a mutual understanding which entails refined shared mental constructs (meaning, values, beliefs, values, etc.)

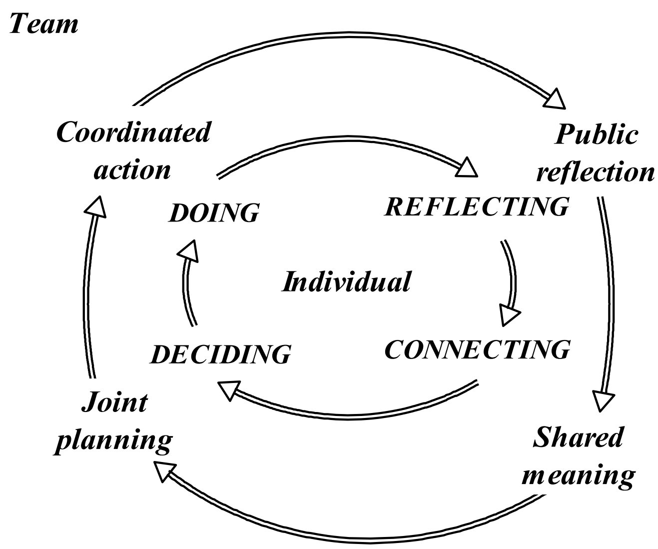

Figure 2. Learning wheel: individual and team (adapted from [20]).

Joint planning: A preparation phase for the subsequent action of the whole team, which can encompass various more or less formal facets.

Coordinated action: Joint planning is not necessarily followed by a joint action, while members of the team follow an agreed agenda of tasks spread over time and space.

Dialogue and discussion

In his seminal book, *The fifth discipline: The art & practice of the learning organization*, Peter Senge [21] cites firm beliefs of two very famous founding fathers of modern physics, Werner Heisenberg and David Bohm, in the importance of dialogue and discussion in the development of science in particular, and society in general. Dialogue and discussion are beneficial and fruitful on several levels - individual, team, discipline – and, conducted properly, are unleashing the full potential of collaborative or team learning. Collectively, we can be more creative, intelligent, and insightful than we can be thinking and acting as individuals.

It is important to be aware of an essential distinction between *dialogue* and *discussion*, both being a type of discourse, as only such awareness allows for their powerful synergy, which could be lost if the difference between the two is not acknowledged. Bohm likened a discussion to a game, in which the arguments about a subject under scrutiny are tossed from one participant to another, with the final goal of winning the argument, virtually regardless of others' views. While in a dialogue, coherence and truth are of the paramount importance, and participants must literally allow the words-meaning (*logos*) to come through (*dia*) and not fruitlessly bounce forth and back.

Bohm suggested that the dialogue should focus on bringing to the surface the "tacit infrastructure" of thought. He was later developing a theory and method of a deeper "dialogue" [22], aiming to allow participants to examine their preconceptions, prejudices and patterns of thought: "*...it is proposed that a form of free dialogue may well be one of the most effective ways of investigating the crisis which faces society, and indeed the whole of human nature and consciousness today. Moreover, it may turn out that such a form of free exchange of ideas and information is of fundamental relevance for transforming culture and freeing it of destructive misinformation, so that creativity can be liberated.*"

The discourse is primarily a way of sharing knowledge and subjecting ideas to criticism. It can also play a creative role with actively improving ideas in collaborative environments concerned with shared understanding.

Collaborative discourse results in the emergence of *new representations* and *shared knowledge*. In group's discussions both the overall group dynamics and individual's collaborative learning emerges from the group's conversation. For a complete understanding of collaborative interactions, both discourse and communication as externally visible distributed *emergent knowledge* and participants' thoughts and actions are needed [23]. In other words, the emphasis is on both representations: individual (mental) ones and socially distributed ones in practice.

A community of practice refers to the creation of a learning environment in which the participants actively communicate and engage the skills involved in an expertise [24]. Such communities are characterized by common intention, personal involvement and mutual dependency. Collaboration in a community can be stimulated by common projects and shared experiences. The participants are engaged in the development of understanding and *knowledge building* through problem identification, research and discourse.

Collaboration, alignment, and distributed cognition

Hutchins [25] pointed out in his studies that *cognition is distributed* across people as they collaborate with each other and with tools designed to aid them in cognitive work, like data gathering, planning, reasoning, and problem solving. The idea is that cognition is not only individual but is also distributed across individuals in a group, other people, and cultural tools and institutions. Especially with such mental tools as language, cognition is distributed not only across individuals and material objects but also across ideas and communication with other people [26].

Distributed cognition refers to cognition and understanding as the interaction among the participants and the tools in the context of an activity. In the context of the workplace rethinking the meaning of expertise is needed. In many cases expert knowledge among professionals is less a matter of what each individual knows than their joint ability to produce a right decision. In other words, expertise is a social affair [27].

Alignment is developed when participants of a collaborative or team group feel involved in their joint engagement (activity). Alignment in a group or community is based on an ability to see and respect each other, on positive interdependence, on individual accountability, and on establishing some common mental models. Building alignment is about enhancing the team's capacity to think and act in a new, *synergistic* manner with coordination and sense of unity.

Effectiveness of a collaborative group depends to a large extent on coordination or alignment among various components of an activity system – participants, materials and technical tools in the environment, cognitive structures (prior knowledge, mental models), and practice of the participants in the subject matter domain of their activities [28].

Our knowledge in the global society is constantly challenged by an increasing complexity, unpredictability and diversity of the world we live in. Thus we are faced with many common problems, which are most frequently ill-defined, open-ended, and very complex, and therefore requiring collaborative or team engagement of scientists and professionals across various domains for discussing, elaborating, explaining, and evaluating solutions from multiple perspectives.

Complex problems are thought to require integration of knowledge from different disciplines [29]. Hence, the team's diversity has to have positive effects on team's performance, and numerous situations are calling for multidisciplinary and interdisciplinary teams with wide range of knowledge and expertise.

As Bruffee [26-27, 30] pointed out: "*In general, heterogeneous decision-making groups work best because ... differences tend to encourage the mutual challenging and canceling of unshared biases and presuppositions ... Groups that are ... too homogeneous tend to agree too soon ... There is not enough articulated disagreement or resistance to consensus to invigorate the conversation ...*" But he also emphasized: "*On the other hand, members of decision groups that are too heterogeneous may have no basis for arriving at a consensus – or no means for doing so: they find that they can't 'come to terms' because they 'don't speak the same language.*"

According to Bromme [31] that means that multidisciplinary teams need to develop sufficient *common ground* (shared cognitive frame of reference). Collaborative environment is very suitable for fulfilling such a task, and ICT tools can be useful for supporting negotiation of common ground in multidisciplinary teams.

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ODLUČIVANJE I RJEŠAVANJE PROBLEMA U EKSPERTNOJ GRUPI: RAZVOJ I UČENJE

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SAŽETAK

Tradicionalna istraživanja odlučivanja nisu znatno doprinijela boljem razumijevanju profesionalnog prosuđivanja i odlučivanja u praksi. Istraživači koji su se bavili odlučivanjem u različitim strukama i prirodnim postavima inicirali su nove perspektive, nazvane naturalističkim, koje su stavile stručnjake u središte istraživanja. Time je istraživanje odlučivanja stavljeno u prirodne situacije.

Ekspertna grupa je više nego skupina stručnjaka. Ona je definirana kao grupa međuovisnih članova grupe s visokom razinom ekspertize vezano za aktivnosti grupe kao i za visoku razinu usvojenosti grupnih procesa.

Nekoliko je napredaka bilo u razumijevanju ekspertize i grupa. Kombiniranjem teorija, modela i empirijskih rezultata nastojimo objasniti učinkovitost i adaptaciju ekspertnih grupa u rješavanju problema i odlučivanju u kompleksnim i dinamičkim situacijama.

Znatan dio istraživanja posvećen je nalaženju karakteristika eksperata i ekspertnih grupa tijekom njihovog optimalnog djelovanja. Te karakteristike se razmatraju kao ulazni, procesni i izlazni faktori. Kao ulazne varijable javljaju se kognitivna, socijalno-afektivne i motivacijske karakteristike. Procesne varijable odnose se na individualno i grupno učenje, rješavanje problema i odlučivanje kako je prikazano u Kolbovom ciklusu učenja, zatim u dubljim strukturama dijaloga i diskusija kao i u pojavama kolaboracije, usklađivanja i distribuirane kognicije. Izlazne varijable tiču se aktivnosti vezanih uz odvijanje predviđenog rada.

KLJUČNE RIJEČI

odlučivanje, paradigma, ekspertna grupa, učenje, adaptacija