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Fundamental knowledge and flexibility of thinking as priorities of management education for technological breakthrough

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Abstract

The article substantiates the need for a radical review of approaches to the training of managers in high technological industries, whose professional activity context is defined by continuous crises, growing uncertainty, dynamic trends, the massive emergence of the newest technical, organizational, and IT solutions, and a profound transformation of markets. Building upon their own research, analysis of expert opinions from top managers, university professors and the best practices of the world's leading universities, the authors identify trends indicating the growing role of the fundamental knowledge possessed by managers, who are capable of raising up to the challenges of an unstable environment. Links are determined between fundamental training and the flexibility of managerial thinking. A conceptual vision is presented of the peculiarities of managerial thinking and of conditions for developing its flexibility in the educational process.

The scientific novelty of the article includes arguments substantiating the need for stepping up fundamental training in line with objective demand for changes in the content of managerial functions. Such training is based on three components: methodology of anticipatory management; scientific and technological foundations of production and technologies of the future; a vision of professional activity and changes that will be brought about by the introduction of new technologies. On the applied side, the authors have designed a concrete structure of fundamental training and a mix of training methods that promote flexibility of thinking and have proved effective as part of Masters in Management programs.

Keywords: managerial training, industry-specific technology, technological breakthrough, fundamental knowledge, flexible managerial thinking, systemic approach, systems engineering, fundamental training, methods and technology of management education

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Introduction

The complex and unpredictable problems of an ever-changing world create significant challenges for organisations and their leaders. To remain competitive, it is necessary to respond to unforeseen changes in a timely manner, carrying out organisational changes dictated by the development of technologies, changing business models, building logistics and interaction with partners and customers on new principles. Foresight and anticipation become imperatives and prerequisites for survival itself. Under these conditions, management needs new intellectual, meaingful methods and tools. At the same time, the dynamics of change is such that classical training is increasingly lagging behind the practical tasks of improving the skills of managers. On the one hand, there comes an understanding that success accompanies not those who have mastered more advanced training courses, but those who have mastered the competencies of self-learning and are well aware of the need for continuous professional development. On the other hand, service support for the process of self-learning, both for individual managers and organisations as a whole ("self-learning organizations"), is becoming urgent.

It is generally recognised that the basis of a specialist's ability to solve new problems independently as well as to self-study, is high-quality fundamental training [Eliseev, 2007; Kosolapova and Kalinovskaya, 2013; Gladyshev, Gladysheva, 2020; Professionals in competition.., 2021]. At the same time, the changes taking place in the context of the tasks solved by management require a revision of the content of fundamental training in management education. The task is very difficult, and only this can explain that many experts, sin terms of the importance and relevance of fundamental education, reduce it to an extended list of classical training courses that are found in programs of various educational areas. Meanwhile, the question of specific proposals for the development of fundamental education remains open. Its constructive solution requires a special analysis and generalisation of best practices, a comprehensive discussion in the expert community.

This study continues the series of articles by the authors on the issues of management education [Gitelman, Kozhevnikov, 2018; Gitelman et al., 2019; Gitelman et al., 2020a; Gitelman et al., 2020b; Professionals in competition.., 2021] in the paradigm of proactive management and the advanced training of managers necessary for its implementation. This article reveals the relationship between fundamental education and other important aspects of managerial activity, which are especially in demand during a period of significant change: the use of new technologies, the transformation of economic systems, and the neutralisation of crisis phenomena.

1. Management has become an extremely knowledge-intensive profession

It should be recognised that modern managers operate in such a rapidly becoming more complex context that science does not have time to comprehend the new, radically different realities that require a new management paradigm.

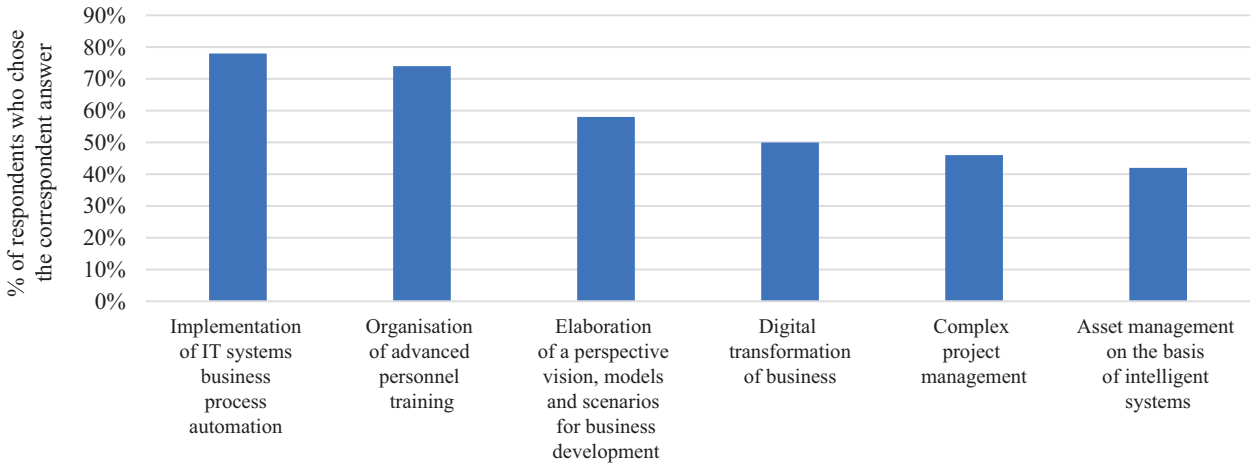
1. Increasing frequency of various shocks (pandemic, geopolitical cataclysms, cyberattacks, significant structural shifts in the commodity and currency markets) multiply the uncertainty in all areas of economic activity and lead to crisis situations. It can be argued that the business community is undergoing a global transformation, the scale, costs, deadlines the results of which cannot be predicted [Medne et al., 2022]. In this regard, there is a sharp increase in the need for new tools for practice: multi-scenario programming based on big data analysis, modern risk assessment methods, mechanisms for ensuring flexibility and adaptability of business configuration.

2. Despite the growing crisis, the industry of the future (industry 4.0) continues to unfold with cyber-physical production systems that connect the virtual space of the Internet with production equipment through a set of network technologies and radically change the industrial architecture. Often at the same time, inherently inertial life supporting infrastructures turn out to be unprepared

Table 1
New knowledge that managers need to implement IT innovations

Area of implementation	Forecasted IT trends	New knowledge necessary for managers
Digital transformation of business	Territorially distributed enterprises Composite Applications Multimodal perception	Remote business management technologies Knowledge in the field of big data analytics for communication with Data Scientists Ability to build the logics of digital applications and basic knowledge of algorithmisation
Cloud technologies	Cloud Platforms Distributed Cloud Services	Opportunities and principles of cloud technology operation, problems associated with their use (including the availability of infrastructure and services) Service delivery models, estimating costs and benefits of using cloud solutions for business
Artificial intelligence	Formative AI Generative AI AI engineering Small volume AI	Principles of operation, possibilities and limitations of the use of AI, factors affecting the effectiveness of AI Modern directions of research in the field of AI, prospects for their application
Process automation	Hyperautomation Expanding the use of IT peripherals Autonomous systems	Understanding the components of hyperautomation, the capabilities of edge computing and autonomous systems, their impact on the business including risk assessment In-depth knowledge of business process design based on the use of AI
Cyber security	Mesh-type networks Differential Privacy AI-security	Fundamentals of business information security Knowledge of major cybersecurity trends
New technologies for working with data	(Data Fabric Decision intelligence Internet behavior Democratisation of knowledge	Principles, capabilities, limitations of advanced analytical tools Mastering data-driven business management Involving employees in the processes of summarising experience, accumulating knowledge and disseminating it within the company
Strategy and structure of business	Total experience Intelligent Composite Business	Building composite business architectures to respond flexibly to rapidly changing business conditions and needs Interdisciplinary knowledge at the intersection of IT, marketing, design, psychology, ensuring the use of generalised experience

Fig. 1. Professional areas of managers experiencing a high need for new knowledge



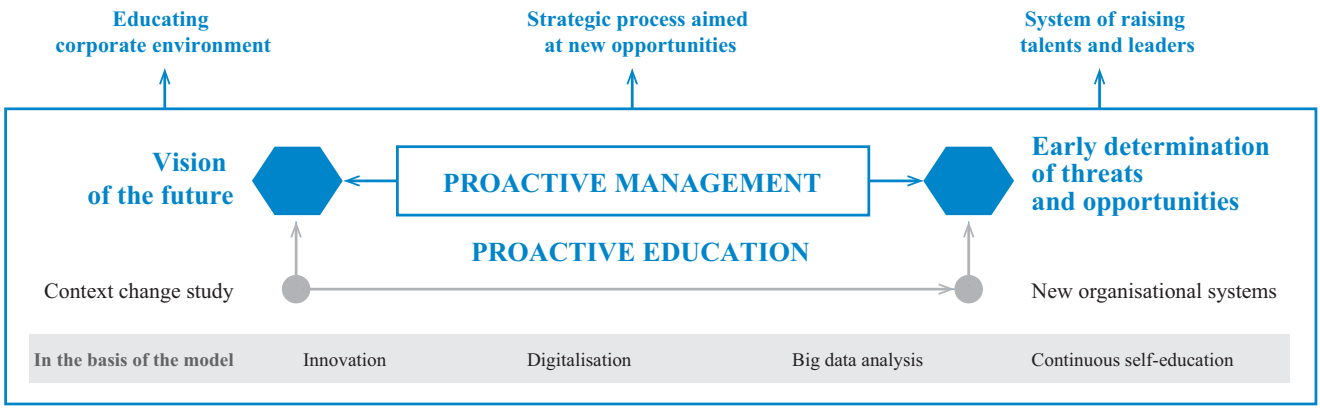
Source: Compiled by the authors based on the results of a questionnaire survey.

for the development of integrated solutions; for example, the electric power industry – to the electrification of new intellectual production facilities for this industry – consumers who put forward special requirements for the reliability and quality of power supply. Completely unprepared for the powerful innovation flow that accompanies industrial changes, the system of vocational education turned out to be also incapable of transitioning to the advanced learning paradigm. As a result, the competencies of managerial personnel do not meet the challenge, primarily in the field of organising innovation and technological breakthrough based on the introduction of the latest scientific and technological achievements and technologies of the future.

There is an urgent need for a broader vision, a holistic view of the context – promising innovations, emerging technological trends, which is fundamentally important in their connection with IT, as well as the associated changes in vocational education.

3. Specialised IT technologies are rapidly developing, which allows to transfer control processes to a highly sensitive mode that takes into account both weak and strong signals [Gitelman, 2020]. Generalisation of changes significant for business in the IT field in recent years, noted in Gartner forecasts [Costello, Rimol, 2019; Karen, 2019; Maddox, 2020; Panetta, 2021; Shein, 2021], IDC [Bayern, 2019; High, 2020; Top ten.., 2021], as well as other reputable researchers [10 breakthrough technologies, 2020; Morris-Reade, 2021], allowed us to identify technological trends that will have the strongest impact on business in the short term and form requirements for a wide range of new knowledge necessary for managers of various functionalities, positions, and market specialisations (Table 1).

Fig. 2. Model of management focused on proactive management and anticipatory training



The statement that among the various areas of professional activity it is in the field of implementing IT systems that new knowledge is especially actively emerging is confirmed not only by theoretical generalisations but also by empirical data. So, in the course of our survey of more than 50 practicing managers and university professors, almost 80% of respondents noted that solving the problems of building an IT infrastructure for companies and automating business processes is accompanied by a high knowledge deficit. The second critical area in this aspect is advanced training (Fig. 1).

4. A fundamental revolution is taking place in the business models of companies: the process of creating added value becomes spatial, and the very concept of "value" is now determined not so much by the set of a particular product useful properties but by the quality of organising consumer access to digital platforms and ecosystems that integrate offers and technological solutions of different market players and involve all interested participants in the process of joint product creation [Trachuk, Linder, 2015; Parker and Van Alstyne 2018].

Technology is the dominant source of business model change. They are the driver that transforms industries and markets beyond recognition, consumer preferences, methods of production, purchase and delivery of products to the end user [Trachuk, Linder, 2015; Kochetkov, 2019].

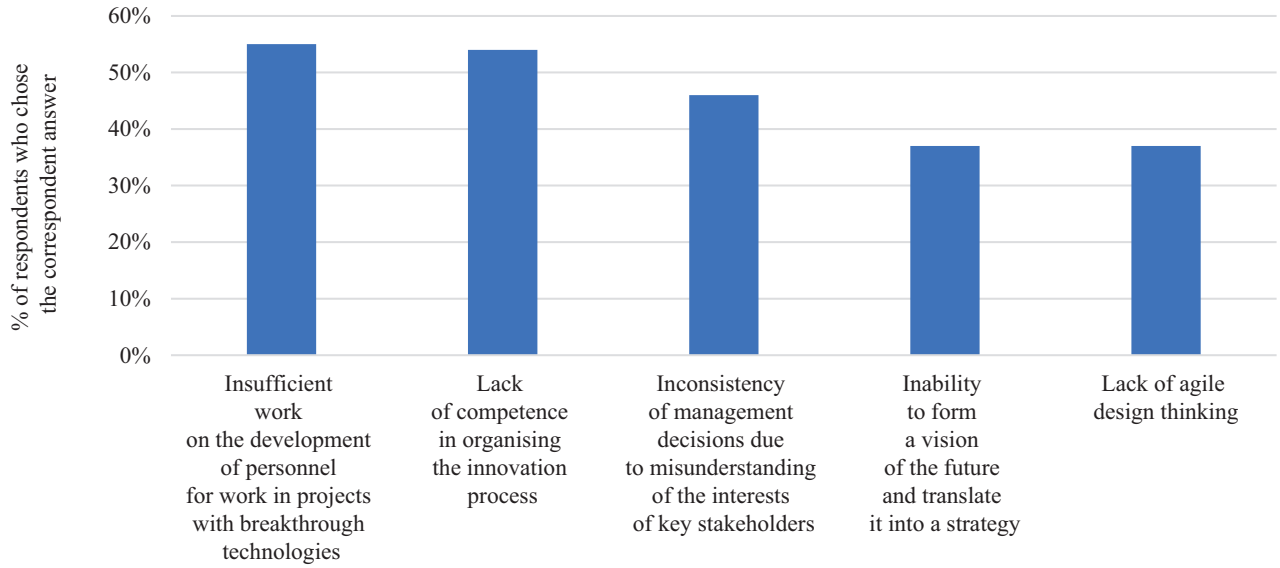
As a result, the taxonomy of organisational systems is becoming increasingly complex, and the systems themselves are becoming fluid and changeable. The most important function of management now is to ensure their balanced and, what is extremely important, advanced development. Management, therefore, must act proactively. The role of the locomotive in solving this problem is given to interdisciplinary teams which include specialists from different subject areas (managers, engineers, business analysts, economists, IT specialists, lawyers) as well as external consultants and mentors [Sailer et al., 2019]. These teams are led by managers with a broad vision of the context, able to control the development of conceptual models that integrate the results of scientific research, engineering solutions, design and art [Francis et al., 2015; Kazemahvazi et al., 2015].

Thus, it can be argued that the challenge for management is that it must become proactive.

Proactive management as a response to the high dynamics of the external environment is a completely different content and scope of activities (tasks) compared to what managers had to do before [Gitelman, 2020]. By proactive management the authors understand a set of technical, organisational, resource and economic measures implemented at all levels of the industry, a specific business, aimed at preventing the negative impact of internal and external factors that threaten sustainability, functionality, competitiveness, economic and environmental efficiency.

Proactive management aims to proactively counter challenges and threats generated by external instability, as well as identifying emerging opportunities as a result of monitoring technology trends, observing weak signals, and structuring complex priorities [Gitelman et al., 2017]. The target function of proactive management is the early preparation of management for unexpected changes and

Fig. 3. Key disadvantages of high-tech business leaders



planned innovations (forward 5–10–15 years), including R&D, human capital development, the introduction of flexible organisational structures, and making a creative corporate environment.

The predictive control model is illustrated by the diagram shown in Fig. 2.

Today Proactive management solution algorithms mean an intellectual revolution in management, radical changes in its paradigm, methodology, organisational systems and processes that cannot be implemented without deep transformations in infrastructure institutions: research and service centers, consulting organisations and, in particular, universities, which more often complex, non-linear problems, are undergoing significant changes and require distributed leadership combined with reliance on continuously updated analytics of both retrospectives and future trends. The subject and content of the work of managers is changing: it increasingly contains human-machine procedures, system analytics, complex algorithms and huge amounts of data. Managers have to interact with many specialists, including external consultants: knowledge bases, forecasting, information security, artificial intelligence. Thus, the modern work of a manager in terms of its information saturation, the variety of tools used, the operational composition of analytics, the dynamism of factors taken into account and the nature of decisions made has become much more difficult than it was a few years ago. It is important to realise that in the foreseeable future, significant changes will continue to occur in the managerial profession and it will become even more intellectually intensive.

In this regard, the following is indicative: in the survey of managers mentioned above, the respondents themselves note insufficient work on the development of personnel, first of all, in those projects that reflect global changes in business architecture: focus on breakthrough technologies and the lack of competencies in organising the innovation process as their main shortcomings (Fig. 3).

2. Background knowledge in anticipatory learning – the imperative of an uncertain context

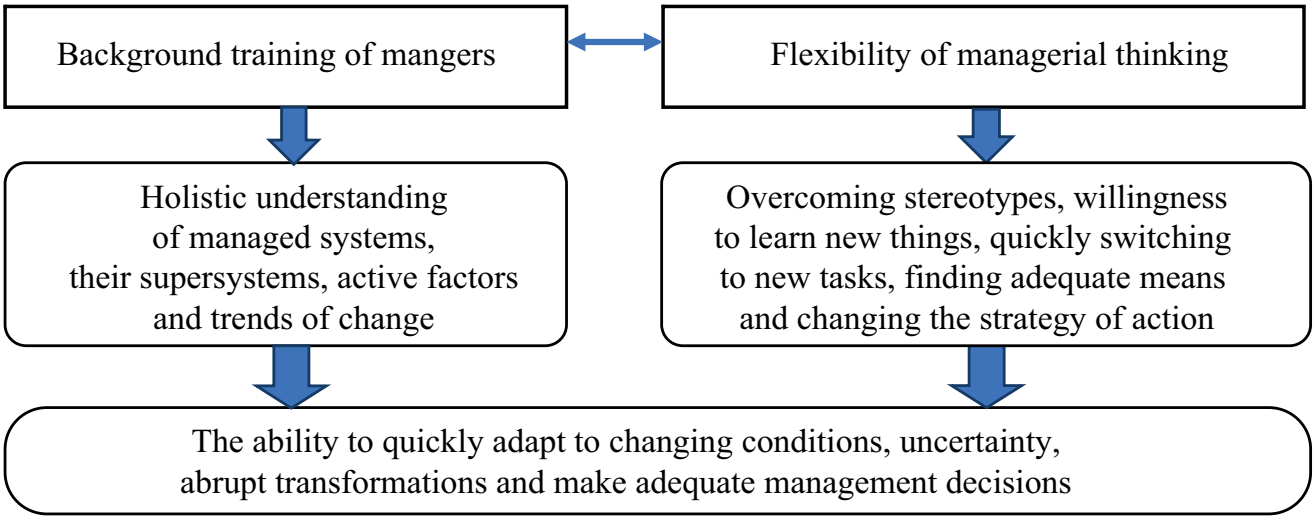
Proactive management is impossible without proactive learning, which is an organised process of building knowledge and competencies to solve future problems that are in line with global trends and national development programs. The purpose of advanced training is to provide specialists with knowledge to work in the conditions of engineering, organisational, economic and socio-humanitarian systems that are being created in the foreseeable future, capable of quickly adapting and rebuilding to a changing industry context, based on new principles and functioning in an external environment with increased turbulence and uncertainty [Gitelman et al., 2019]. It should be noted that advanced training can be implemented at various levels of education (bachelor's, master's, MBA, PhD, DBA programs), but in different volumes: it is obvious that the higher the qualification level of the program, the more issues of advanced training are considered in it.

Fig. 4. Approximate structure of fundamental training in management master's programs

TOPICS OF FUNDAMENTAL TRAINING

KNOWLEDGE AREA	PROACTIVE MANAGEMENT METHODOLOGY	SCIENTIFIC AND TECHNICAL FOUNDATIONS OF PRODUCTION AND TECHNOLOGIES OF THE FUTURE	VISION OF PROFESSIONAL ACTIVITY AND ITS CHANGES
Development of complex systems	Intelligent systems for predicting changes	Self-design business development	Management professionalism basics
Technological and socio-economic trends	Strategic analytics	Monitoring and analysis of weak signals	Future research methods
Future design	Organisation of applied research and development	Platform markets and ecosystems	Conceptual design

Fig. 5. Unity of fundamental training and flexibility of managerial thinking



Proactive management and proactive learning focused on anticipating the future are inextricably linked and critical to the successful implementation of a technological breakthrough. At the same time, the characteristics of advanced learning objects, which are super-complex non-linear problems, determine fundamental differences in the content and methods of training managers, which form competencies and knowledge, primarily of a fundamental nature, corresponding to current and future tasks.

However, the question immediately arises: what fundamental knowledge, its content and depth of study are we talking about? Leading foreign universities are actively developing research and training of managers in such issues as systems engineering, future technologies, stability and adaptability of complex systems, network technologies and distributed architectures, data science, conceptual design, chaos management, self-organisation. Unfortunately, in this regard, our country is still in a catch-up mode.

Our analysis of English scientific publications [Wu et al., 2004; Nine major paradigm shifts.., 2018; Management skills.., 2019] shows that the focus is on fundamental training in the following areas of managers.

1. Interaction of managers with technologists, designers, product designers, economists, environmentalists when deciding on the choice of the most efficient production and information and telecommunication technologies for the implementation of specific projects. It is noted that this group of competencies is especially significant for industries with a high potential for danger, in which the risks of using incorrect design and technological solutions can cause catastrophic consequences [Bell, Wechsler, 2015]. That is why the services of technology consultants are extremely expensive, and therefore, managers need to be trained in the basics of technology from the very beginning of their professional activities.

2. Ability to adapt acquired knowledge to solve non-standard, complex problems; formation on this basis of a personal arsenal of methods for solving complex, uncertain problems; possession of a culture of self-learning with a rapid build-up of missing knowledge from non-core areas.

3. Conceptualisation: the ability to apply creative thinking to generate new ideas and translate them into various conceptual and visual forms. Conceptualisation also includes the ability to diagnose and systematise problems, form a holistic vision of the situation, predict the threats that management will face in the foreseeable future, and those unique opportunities that need to be used, create a system for managing unpredictable risks and organise early readiness to solve new problems [Pettinger, 2016].

4. Communications: the ability to work productively in professional communities and establish interactions between stakeholders aimed at achieving a common result. This category also includes the skills of organising the work of experts from different professional fields, primarily the establishment of a single communication-conceptual apparatus [Nine major paradigm shifts.., 2018].

The third and fourth areas of activity in a number of publications devoted to issues of leadership and managerial power [Valk et al., 2011; Bell, Wechsler, 2015], are combined into one large group, which can be conditionally called ideological, or "the ability to read the world and predict its development." Arguing its

importance, C. Bell and G. Wexler emphasise that the meaning of this skill is to help other employees realise that the well-known classical paradigms of resource management, marketing, logistics or organisational design no longer work in the modern world and that these paradigms must be reconfigured in according to the context – global, industry and market [Bell, Wechsler, 2015].

It is very interesting to look at the composition of managerial competencies by A. Amini [Amini, 2016], who distinguishes 28 types of them, grouped into several blocks: (1) setting priorities, clear goals and making effective managerial decisions; (2) management of people and teams (delegation of authority, motivation, mentoring, work discipline); (3) the art of "behaving in public"; (4) continuous self-development and learning; (5) intelligence - a block that can be defined as the level of "internal power" of the leader, allowing him to simultaneously manage various resources and subsystems of organisations.

One of the main tasks of fundamental training is to build a systematic vision of one's professional activity at the level of knowledge for theoretical understanding of changes in its content and practical solution to the problems of its improvement. [Professionals in competition.., 2021]. In the educational process, it is necessary to provide an understanding of the interdisciplinary relationships between the objects of management and the systems in which they operate. In our opinion, the current areas of fundamental training of managers are: (1) the methodology of proactive management; (2) scientific and technological foundations of production and technologies of the future; (3) a vision of professional activity and the changes that will occur in it as a result of the introduction of new technologies, both technical and organisational, economic and social. These three criteria determine the topics of the relevant academic disciplines and their general structure in the educational program (Fig. 4).

Within these areas, the content of the fundamental training of managers changes significantly at different levels of education: from specific scientific areas (economics, engineering, computer science, etc. [Professionals in competition.., 2021]), studied at the first level of higher education, to the content of complex objects and processes in which fundamental sciences are integrated with applied sciences (development of complex systems, strategic analytics, designing the future), which should be studied in a management master's program. As a result, fundamental training becomes as interdisciplinary as possible, which, on the one hand, allows expanding the range of relationships and the scope of students' vision, and on the other hand, makes it necessary and even forced to develop their flexibility of thinking.

A holistic understanding of production, organisational, economic systems, including markets, their relationships, trends of change and management decision-making tools is formed in the process of fundamental training of managers in the study of disciplines that contain the main patterns of knowledge area of the profession. Understanding these patterns, which do not change quickly and under the full influence of even abrupt transformations in the conditions of the activities of organisations, allows managers to correctly navigate in unexpectedly difficult situations, form their understanding and a common vision for the further development of the business. The flexibility of managerial thinking at the same time allows you to quickly overcome the stereotypes of behavior that have developed in the previous period of activity, see new problems, rebuild the understanding of the changed environment, set new tasks in a timely manner, change your paradigm and find adequate management solutions that ensure the preservation and development of business. In the modern world, these factors of training managers who are able to overcome problems, solve complex task and see the prospects that shape the future are becoming more significant and highly demanded (Fig. 5).

Of course, for the rapid adaptation of a university graduate to practical activities, special training is also necessary. In contrast to the fundamental one, this is the formation of readiness for effective work to solve known problems. According to our estimates, it should be from 20 to 30% of the volume of educational programs and must be present, since the manager must be able to solve typical organisational problems and use the existing methods and tools for this. He must be ready not only for changes, but also for current activities, in which typical tasks remain relevant for one time or another.

The fundamental part of education is not characterised by the permanent content of education. It changes, but much more slowly and dosed compared to the specialised one. At the same time, monitoring the overdue necessary changes in the content of fundamental training and making appropriate corrections to it becomes an important task for the organisers of management education.

Thus, on the one hand, a holistic understanding of engineering, organisational, economic systems and trends in their changes, formed in fundamental training, and on the other hand, the flexibility of thinking, formed in a properly designed training content and methods for organising its assimilation, provide the ability of managers quickly adapt to turbulent phenomena in the external environment and adequately respond even to sudden changes in business management conditions.

An analysis of the development processes of a business environment of various scales, educational programs of leading domestic and foreign universities, as well as the latest tools that determine the effectiveness of the activities of modern business leaders, allows us to identify popular topics for strengthening fundamental training in management master's programs. These include courses or individual topics that can be represented as the main components of the content of interdisciplinary courses

that correspond to our conceptual approach [Gitelman et al., 2020a; Professionals in competition.., 2021]. For example, as such, you can specify the following.

1. *Conceptual foundations for the non-linear development of the managerial profession:*
   - internal mechanisms and external factors of professional development;
   - a strategy for anticipating the need for new competencies;
   - management of advancing creation of new value.
2. *Scientific and technical foundations for the development of sectoral and intersectoral production complexes:*
   - promising technologies;
   - security of organisations and cyber systems;
   - big data analytics;
   - innovative business ecosystems.
3. *System engineering methodologies for business development management:*
   - scaling in sociotechnical systems and systems-of-systems;
   - overcoming the increasing complexity of systems and contexts;
   - ensuring adaptability and flexibility of systems and processes for their creation and maintenance.

The conceptual foundations of the non-linear development of the managerial profession form the student's potential for self-development, readiness to master new skills in connection with ongoing changes in the external environment that transform the content of the profession. A deep understanding of the specifics of one's profession and the multifactorial mechanisms of its change forms the methodological culture of a practical specialist, creating the possibility of successfully mastering the interdisciplinary and special disciplines of the training program, as well as the willingness to independently deal with new problems and master new types of knowledge. In addition, its practical significance lies in the fact that it lays the scientific basis for most professional competencies, the formation of which is completed in the disciplines of specialisation and continues to develop in experience. A conceptual understanding of one's activities also allows one to competently build the trajectory of one's career movement, in the implementation of which ambitions correspond to the abilities and potential of professional development. The conceptual vision of professional activity is an important factor for the full realisation of the potential of a specialist.

Understanding the scientific and technical foundations for the development of sectoral and intersectoral production complexes is aimed at obtaining knowledge about the features and patterns of functioning of specific production operations, markets, and industries. Without this knowledge, it is impossible to form a holistic vision of the objects and tasks of one's activity, and especially an understanding of their development trends, and, accordingly, the formation of readiness for at least the near future.

The increasing complexity of the systems that the manager deals with requires special attention to fundamental knowledge in system engineering methodologies. The inclusion of this discipline in the curricula of bachelor's and master's programs in management implemented at the world's leading universities (MIT, Stanford University, Harvard University, Technical University of Aachen, Insead Business School and many others) is due to the growing complexity of systems, the intensity of their interaction with the environment and, consequently, the need to increase systemic literacy. It is system engineering, on the one hand, that makes it possible to carry out a theoretical understanding of the patterns of system development forming a system approach that is so significant today for a modern manager, and on the other hand, it offers specific practical tools for solving complex problems embodied in standards, sets of management principles, methodologies for creating elastic (resilient) and flexible (agile) systems.

The current field of system engineering includes solving the problems of creating sociotechnical systems and megasystems, ensuring the scaling and development of systems of any level, including systems-of-systems and the methodology of soft systems [Gavrilova et al., 2017; Systems engineering vision., 2021]. Thus, research and development in the direction of designing human activity systems (Human Activity Systems, HAS) makes it possible to highlight the general patterns of HAS and the specifics determined by the level of system complexity being designed [Calvo-Amodio, Rousseau, 2019]. The use of these patterns and proven methodologies significantly increases the competence of managers in the field of conceptualisation and communication.

The dynamism of the external environment, the increasing speed of change require the created systems to be elastic (resilience) – the ability to cope with adverse conditions and events through preliminary preparation and planning, countering destruction, recovering from failure and successfully adapting to changes and destructive influences. Systems that are required to provide a given functionality for a long time must be able to anticipate, synchronise, proactively learn and respond [Hollnagel et al., 2006]. Studying the practice of creating and using such systems made it possible to identify characteristic features in system engineering and formulate the principles and methodologies of flexible design [Hollnagel et al., 2006; Jackson, 2010; Jackson, Ferris, 2013]. Mastering this area significantly increases the innovative potential of managers, allowing them to confidently act in the face of unforeseen changes in the situation, create, manage and directly participate in interdisciplinary teams. Thus, in order to understand the prospects and succeed in a dynamic environment, managers need to master the accumulated experience and follow the results of new developments in

the field of agile system engineering [Dove, 2005]. The principles and methods applied in it require a creative approach, the ability to assess uncertainties, choose ways to respond to changes based on the goals and abilities of the organisation. Agile methodologies require from all participants an innovative approach to solving problems, the ability to take calculated risks, and respond in a timely manner to emerging threats and opportunities, in connection with which the flexibility of thinking becomes a necessary condition for the activities of managers.

3. On the agenda – increasing the flexibility of managerial thinking

Flexibility of thinking is one of the foundations of modern managerial professionalism. A manager who does not have flexible thinking is not capable of innovative activity and cannot be effective in dynamically changing conditions, and even more so in situations characterised by uncertainty.

The flexibility of managerial thinking is the ability to quickly switch to new tasks and correctly select effective methods and tools for solving them. To do this, it is necessary to have the ability to overcome the prevailing stereotypes and patterns, assimilate new ideas, hypotheses, identify and establish hidden connections and change the strategy of action depending on the specific situation [Professionals in competition.., 2021]. In general, the flexibility of thinking is closely related to the ability to adapt to the new and creative abilities.

Another approach to analyse the flexibility of managerial thinking is to determine the variety of mental models that are necessary to successfully solve complex problems. In this context, the flexibility of managerial thinking lies in the manager's ability to use different types of thinking: critical, systemic, conceptual, analytical, design, strategic, cost and emotional intelligence. Flexibility is primarily determined by the extent to which the manager owns all these types of thinking and is able to consistently or in a certain combination use their intellectual abilities in relation to different or the same objects, tasks, situations. The greater the number of types of thinking and the higher the level of their possession in the manager's arsenal, the higher the level of flexibility of his professional intelligence.

Thus, managerial activity is a multidimensional intellectual activity in which a wide range of different types of thinking is implemented in consistent and integrated forms.

In the process of improving the management magistracy and orienting it to specific industries, the task of selecting students with a certain basic training becomes relevant. If this task is solved according to the criteria of successful formation of managerial thinking flexibility, then, in our opinion, a choice should be made in relation to students with basic engineering, economics and natural science education.

For example, engineering activity in general, in all its many specialisations and varieties, as well as managerial activity, is characterised by a wide variety of mental models. Some authors believe that engineering activity includes technical, constructive, research and economic types of thinking [Mustafina et al., 2010]. Others include logical, figurative-intuitive, practical, scientific, aesthetic, economic, ecological, ergonomic, communicative, creative thinking [Stolyarenko, Stolyarenko, 2001; Nagornyak, 2012]. Also, engineering thinking is considered in a generalised form as "a complex systemic formation, including the synthesis of figurative and logical thinking and the synthesis of scientific and practical thinking" [Sazonova, Chechetkina, 2007]. Most authors single out logical, creative, visual-figurative, practical, theoretical, technical, spatial thinking in engineering thought. Consequently, a highly qualified engineer, and to some extent a well-trained graduate of an engineering bachelor's and specialist's degree, has many types of thinking, thanks to which he develops a “multi-screen” vision of professional tasks and gains the ability to identify and overcome technical contradictions and physical contradictions hidden in them.

When comparing managerial and engineering thinking, a conclusion arises about their similarity in terms of diversity (“multi-screen”), consistency, as well as their creative basis. However, the difference lies not only in separate individual varieties of thinking (technical for engineers or emotional for managers), but also in the features of the content of mental models that are common to them by name. The main differences in their thinking lie in the context of its application. Management and engineering activities are undoubtedly interdisciplinary, but the content and range of interdisciplinarity are significantly different. In engineering tasks (perhaps excluding the largest intersectoral scale) interdisciplinarity is characterised by closer areas of knowledge than in organisational and managerial ones. Therefore, the use of different types of thinking and their composite combinations in solving the professional tasks of a manager and an engineer always differs significantly. If we take into account the content of these tasks, then we can talk about the existence of even fundamental differences in their professional thinking.

Due to the variety of mental models required in engineering, it, of course, has a certain, and for some specialists, high flexibility. Nevertheless, as the analysis shows, when mastering the managerial profession, specialists of any profile need to form a new type of professional thinking and develop its managerial flexibility. The flexibility of thinking in one profession does not automatically transfer to the content of another, if it is not purposefully developed during its development, primarily because the interdisciplinary content of activity and the composition of mental models change.

In management education, when recruiting students with any engineering specialisation, the task of forming strategic, conceptual, cost and development of critical, systemic and project thinking, as well as emotional intelligence arises. When solving this problem, especially in terms of the formation of managerial thinking, the methods and technologies of teaching, methods of working with educational content are of high priority. The content of disciplines, of course, also significantly affects the development of professional thinking, but still to a lesser extent than the methods and technologies of working with it.

The authors in the process of preparing managers pay considerable attention to the formation of managerial thinking in them. Therefore, in addition to common teaching methods and technologies (case studies, problem-based learning, role-playing games, team and individual project work, webinars), specially developed methods, technologies, organisational and methodological tools are also used, which, in particular, include: conceptual design, intellectual and business games "GO to the heights of mastery", advanced training based on research work, innovative tours and excursions, communication platforms, a joint innovation arena of the university and business, self-design of professional development, project-based learning together with business, etc. [Professionals in competition .., 2021]. The complex application of these methods in the educational process of master students provides a significant effect in the formation of managerial thinking and the development of its flexibility (Table 2).

These methods influence not only the formation and development of the flexibility of professional thinking among students of the master program in management, but also their motivation for learning and the readiness of future managers to work with a wide variety of new tasks and situations that the near future creates for them.

Conclusion

In the context of constant changes in the content and context of managerial tasks objectively causing a systemic complication of managers' activities, the role of their fundamental training and flexibility of thinking is increasing. Despite the high stability of fundamental knowledge, their content for the dynamically developing managerial profession, although slowly, is still changing. Determining the composition of fundamental education that ensures successful adaptation of managers to problems with new content and uncertainty in high-tech industries is a special research task that is becoming one of the most relevant in management education. The results of the authors' research made it possible to identify a number of topics that should strengthen fundamental training in management education programs. They are presented in three interdisciplinary blocks: the conceptual foundations of the non-linear development of the managerial profession; scientific and technical foundations for the development of sectoral and intersectoral production complexes; system engineering methodology in business development.

An analysis of the data available in the literature and our own research show a close relationship between fundamental education and managerial thinking. Possession of fundamental knowledge develops systemic and conceptual thinking, contributes to the growth of the flexibility of managerial thinking, the role of which increases dramatically in the professional activities of a manager. In this regard, the flexibility of managerial thinking should become one of the independent goals of training managers. The difficulty of realising this goal, which is difficult to formulate in terms of competence, lies in the fact that it cannot be achieved by creating a separate training course, because this key soft skill is formed in the process of integrating all types of cognitive, educational and practical activities with contents of various disciplines. Therefore, the main factor in the development of the flexibility of managerial thinking is the variety of methodological tools in the educational work of students and its compliance with the best management practices. The presented methods and tools for the implementation of the educational process have the universality of application both in individual training courses (fundamental and applied), and in the integrated interdisciplinary content developed by the authors, providing the acquisition of experience with new knowledge in solving practical business problems.

Renewal of fundamental training adequate to objective changes in the content of the activities among managers of high-tech organisations and the targeted development of the flexibility of managerial thinking in the context of the entire educational process are key areas for the development and implementation of the advanced training concept for leaders of a new generation.

Table 2
Teaching methods that develop the flexibility of managerial thinking

Name of the method	Key characteristics	Student learning activities	Application result	Author's experience
Problem-based learning combined with innovative activities	Problematisation of educational content and creation of a problem situation for educational work	Analysis and identification of contradictions in a real situation. Search and concretisation of their causes. Development of ways to resolve contradictions, the formation of of new knowledge system	Development of critical, analytical and system thinking	"Preparation of breakthrough teams" technology has been introduced. More than 100 specialists from Ural Federal University, PJSC "T Plus", "Bashkirenergo" were trained under technology
Conceptual design	Project task based on the current situation in an organisation or industry that requires a holistic radical solution	Active use of theoretical concepts and categories to search for guidelines and new opportunities in solving complex uncertain situations. Formulating and substantiating new ideas, creating a vision of the final solution that ensures the development of the organisation	Active use of theoretical concepts and categories to search for guidelines and new opportunities in solving complex uncertain situations. Formulating and substantiating new ideas, creating a vision of the final solution that ensures the development of the organisation	A conceptual design workshop has been created. The courses "Proactive Management", "Designing Digital Platforms and Ecosystems", "Visual Analytics and Design Thinking" are being implemented
Organisational and activity games	Organisation of team and consulting work on solving complex problems by teams in a short time	Analysis of tasks and problem situations with the formulation of questions for intermediate solutions and a common vision. Consideration of technical, legal, economic, personnel, environmental, and other aspects in interconnection and their integration into a complete picture to generate system solutions. Development of a conceptual design for solving a complex problem	The development of collective thinking skills, in which all types of managerial thinking are formed, its flexibility is actively developed. Expanding the range of opportunities for applying intellectual skills and acquired knowledge	More than 70 games were held, including games at Russian nuclear power plants. The total number of participants in the games over the past 10 years has exceeded 1000 people. (students and young business professionals).
Innovative tours and excursions (real and virtual)	Overview lectures, discussion panels, round tables, introduction to practical experience in companies and at real production facilities	Understanding new experience, comparing it with previously known, identifying its advantages and disadvantages, searching for opportunities to use it in other conditions and situations	The development of critical, analytical and systemic thinking when getting acquainted with new practical experience, as well as other types of managerial thinking, according to the object of innovative practice	Excursions are regularly held to the advanced facilities of Rosatom, Rosseti, T Plus, IDO Ural. The practice of virtual excursions (Ridero) has been initiated. Foreign internships are organised at leading universities

Table 2 (*continuation*)

Name of the method	Key characteristics	Student learning activities	Application result	Author's experience
Communication platforms	Exchange of opinions, assessments and judgments on topical issues and tasks of management practice	Involvement in new issues and tasks through the analysis and modeling of their content, the formation of relationships between new experience and existing knowledge	Development of systemic and communicative thinking, as well as emotional intelligence	More than 10 network communication platforms have been created with business partners, domestic and foreign universities. Interdisciplinary scientific and methodological seminars are held on topical issues of management
Project-based learning in the format of smart partnership with business	Actualisation of interdisciplinary issues. Discussion of project development stages and criteria for their evaluation	Generating ideas for choosing the subject of design work. Coordination of organisational and managerial projects by partner companies. Development, system analysis and correction of design solutions. Assessment of resources for their implementation. Public presentation and protection of projects in a partner format	Development of critical, systemic, cost and project thinking. Mastering teamwork skills	Participation of students in corporate projects. Presentation of projects on different training modules for discussion at corporate seminars of business partners

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