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FEEDBACK SUPPORT SYSTEMS: THE ORETICAL BASIS

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Abstract: This article analyzes the theoretical foundations of feedback support systems. The feedback process is considered as a means of enhancing efficiency in human-computer interaction, education, manufacturing, and service sectors. The paper examines the developmental stages of these systems, their scientific theories, and possibilities for integration with modern technologies. The theoretical foundations are studied in connection with cybernetics, communication theory, and pedagogical technologies. In addition, the importance of feedback systems in improving user experience and the principles of their effective operation are also highlighted.
Keywords: feedback, support system, communication theory, cybernetics, pedagogical technologies.

ENTRANCE

The concept of feedback is one of the processes that is of great importance in various areas of human activity. It was initially introduced into scientific circulation within the framework of research on the management of technical and natural systems, in particular, within the framework of the theory of cybernetics developed by Norbert Wiener. In the theory of cybernetics, feedback is interpreted as a mechanism that allows optimizing the future operation of the system by processing the output results of the system and transferring them to the input data. This mechanism plays an important role in any management process, from living organisms to complex technological systems . Over time, the concept of feedback has gone beyond the boundaries of technology and has become widely used in psychology, pedagogy, communication theory, management sciences, and modern information technologies.[1]

Today, feedback systems are considered an important tool not only in controlling and managing processes, but also in many areas, such as increasing the efficiency of interaction, improving human-computer interfaces, improving user experience, and individualizing the educational process. For example, in the education system, feedback from teachers to students serves to increase the level of knowledge of students, eliminate their shortcomings , and strengthen their motivation. In production, the feedback process between managers and employees serves as a decisive factor in increasing efficiency, improving the quality of work, and making strategic decisions. At the same time, the rapid development of digital technologies has made it possible to automate and optimize feedback systems .

The widespread use of information and communication technologies has led to the fact that feedback processes have become faster and more interactive. For example, online learning platforms can instantly analyze student test results or assignment answers and provide automatic recommendations. This allows for real-time optimization of the learning process. Systems based on artificial intelligence algorithms can analyze user behavior and provide feedback tailored to individual needs. As a result, feedback systems are considered not only as a means of providing information, but also as an intellectual mechanism that increases personal development and process efficiency.

However, the effectiveness of feedback systems directly depends on their proper design, adaptation to user needs, and the accuracy and relevance of the information. Effective feedback should be provided in a timely manner, be clearly targeted, and be understood by the user. Otherwise, incorrect or late feedback can lead to misunderstanding, decreased motivation, and incorrect decisions by the user. Therefore, a deep study of the theoretical foundations of feedback systems, the use of scientific approaches in their design, and their integration with modern technologies remain an urgent issue .

Theoretically, three main scientific foundations are important in understanding the feedback process: cybernetics, communication theory, and pedagogical technologies. Cybernetics interprets feedback as a key element of control systems, through which the system is goal-oriented. Communication theory, on the other hand, sees feedback as an integral part of the information exchange process and analyzes it as a two-way communication mechanism between the sender and the receiver of the message.[2] In pedagogical technologies, feedback is a key tool for improving the quality of the learning process, monitoring the stages of student development, and increasing the effectiveness of mastering.

Also, in modern practice, feedback systems are often multi-level and flexible, operating based on user profiles, behavior and needs. Artificial intelligence, big data analytics, IoT and cloud technologies serve as the main technological basis. For example, companies are able to analyze feedback data from customers and improve product quality, personalize services and optimize marketing strategies.

In the future, feedback systems are expected to become more intelligent, personalized, and proactive. This will not only improve the user experience, but also significantly optimize the decision-making process. At the same time, the ethical aspects of these systems, as well as the issues of data confidentiality and transparency, remain relevant. Therefore, a deep study of the theoretical foundations of feedback systems and their correct application in practice is of great scientific and practical importance.

OF RELATED LITERATURE

The concept of feedback is widely discussed in the scientific literature, and its early theoretical foundations are associated with cybernetics and control theory. Norbert Wiener's work “Cybernetics: Or Control and Communication in the Animal and the Machine” (1961) interprets feedback systems as a central element of control processes. Wiener presents feedback as a mechanism that adjusts the system's activity by processing the system's output data and transferring it to the input data. Although this theory was initially aimed at explaining technical and biological systems, it was later applied to social and pedagogical processes.

Within the framework of classical communication theory, Claude Shannon and Warren Weaver's The Mathematical Theory of Communication (1949) explains feedback as a two-way communication mechanism between the sender and receiver in the process of information exchange. They argue that effective communication occurs not only in one direction, but also when there is feedback . This approach is also currently used in human-computer interface and user experience design.

Feedback research in the educational field is extensively reviewed by John Hattie (2009) in his book Visible Learning. Hattie, based on meta-analyses, has shown that feedback has a significant impact on student learning . He argues that clear, timely , and purposeful feedback is one of the most powerful motivational and cognitive factors in student learning. Psychology and performance improvement, Avraham Kluger and Angelo DeNisi (1996) analyzed the effectiveness of feedback interventions in their article “The effects of feedback interventions on performance.” Their study shows that while appropriate feedback increases performance, inaccurate or unnecessary feedback can have the opposite effect.

In the field of information technology, the definition of feedback systems given by Ramaprasad (1983) is of particular importance.[3] He defines feedback as a process by which information

received by a user or system is used to influence future actions . This definition is currently widely used in artificial intelligence, IoT , and adaptive learning systems.
Modern research, particularly in the IEEE and Springer databases, has highlighted the need for real-time feedback systems, adaptive algorithm-based recommendations, and personalized approaches based on user profiles. For example, adaptive learning systems based on artificial intelligence analyze student behavior and provide personalized learning materials. This significantly increases efficiency compared to traditional approaches.
At the same time, the literature also mentions the shortcomings of feedback systems. In particular, it is noted that incorrect or late feedback can reduce user motivation and lead to poor decision-making. Also, issues of user data confidentiality, ethical principles , and transparency are relevant.
In general, a review of the scientific literature shows that research on feedback systems has developed in three main directions: the development of theoretical foundations, the creation of practical models, and integration with modern technologies. This requires a comprehensive approach to the effective use of these systems.

RESEARCH METHODOLOGY

This article uses a comprehensive research approach to study the theoretical foundations of feedback support systems. The research methodology includes the stages of analysis of theoretical sources, synthesis of scientific literature, comparative analysis of existing models , and integration of conceptual approaches. The main goal in choosing a method was to deeply explain the essence of feedback systems, determine their theoretical foundation , and assess the degree of compatibility with modern technologies.
At the first stage, a bibliographical analysis of scientific literature was carried out. In this, the main scientific sources on cybernetics, communication theory, pedagogical technologies and information and communication technologies were studied. The works of scientists such as Norbert Wiener, Claude Shannon, Warren Weaver, John Hattie, Avraham Kluger and Angelo DeNisi played a fundamental role in determining the scientific foundations of this direction. Articles published in the last decade from the IEEE, Springer, Scopus and Google Scholar databases were also analyzed. The literature selection process included scientific articles, monographs, technical documents and practical research reports.
At the second stage, a conceptual model of feedback systems was developed using the method of theoretical analysis. This model was based on the integration of three main theoretical approaches - cybernetics, communication and pedagogical technologies. Within the framework of the cybernetics approach, feedback systems were considered as an integral part of management processes, and mechanisms for optimizing future actions based on the output signals of the system were studied. The communication approach interpreted feedback as a two-way information exchange process, showing the need to ensure the continuity of communication between the sender and receiver of the message.[4] Within the framework of pedagogical technologies, feedback was assessed as an important tool for improving the quality of the educational process, identifying the stages of student development and increasing the effectiveness of mastering.
In the third stage, a comparative analysis method was used. In this, the differences, advantages and limitations between traditional feedback systems and modern, digital-based systems were identified. In traditional systems, feedback is usually given verbally or in writing, with a certain time delay, which results in a delay in the user's response. In modern systems, real-time information exchange, automatic analysis based on artificial intelligence , and the possibility of providing personalized recommendations are available. To more clearly illustrate these differences, practical examples from the fields of education, manufacturing , and service were analyzed.
In the fourth stage, the conceptual integration method was used. This approach combined various

scientific theories to develop a general theoretical model of the feedback system. The model included three main components: data collection and analysis, formulation of recommendations and their delivery to the user. Technological aspects were also included in this model - artificial intelligence algorithms, big data analysis, IoT devices and cloud platforms.[5]
case studies were analyzed on the principles of operation of modern feedback systems . This included automatic assessment systems in educational platforms, employee assessment platforms in corporate management, and mechanisms for optimizing product quality based on customer feedback in e-commerce. In each case, the feedback strategy used by the system, the level of interaction with the user, and performance indicators were evaluated.
The research also used a content analysis method. This method was used to extract key ideas about the advantages, disadvantages, mechanisms of operation, and future development trends of feedback systems in scientific articles, case studies , and technical documents. The analysis focused on real-time feedback, personalized learning systems , and user experience-based design approaches.[6]
All theoretical and practical information obtained within the framework of the methodology was synthesized and general scientific conclusions were drawn. This approach allowed us to develop scientifically based recommendations to ensure the effective functioning of feedback systems. As a result, the methodology developed within the framework of the article created the opportunity not only to consolidate theoretical knowledge, but also to apply it in practice.
Allowed for a comprehensive and systematic analysis of the study of feedback systems. The scientific foundations of this field were strengthened through a thorough study of theoretical sources, a comparative analysis of modern technologies , and the creation of a conceptual model. [7] The practical value of the research results is that they can be used in the design and optimization of future feedback systems.

ANALYSIS AND RESULTS

And practical research conducted in this study, a number of important scientific conclusions were identified regarding the main theoretical foundations of feedback support systems, their practical application and development prospects. The analysis process was based on in-depth processing of the data obtained during the stages of bibliographical analysis, conceptual integration and comparative analysis presented in the methodology.
First of all, the study showed that feedback systems are an integral element of the control cycle defined in the theory of cybernetics. As described by Norbert Wiener, any control system adjusts its activities based on information obtained from the output results. This theoretical basis is fully valid for modern feedback systems. However, the analysis showed that in modern systems, unlike the classical model, the feedback process often occurs in real time, at high speed and with a multi-source information flow.[9] This determines the important role of technologies such as artificial intelligence and big data analysis in processing the information flow .
According to the research results , feedback systems built on the basis of communication theory enhance two-way communication between the user and the system. Within the framework of the Shannon–Weaver model, the compatibility between the transmitter, channel, message and receiver elements, as well as the minimization of noise factors, directly affect the efficiency of the system. The analyzed modern platforms showed that the design of the user interface, visual and auditory signaling mechanisms, as well as customized responses are crucial in increasing the efficiency of the system.
The results of the study in the context of pedagogical technologies confirmed that feedback serves not only as a means of correcting errors in the learning process, but also as a means of motivating the learner, developing self-control skills, and forming individual growth strategies. Although the meta-analyses conducted by John Hattie noted that the impact of feedback on academic achievement is high , the results of our study showed that the effectiveness of this impact depends on the speed of feedback, the provision of specific recommendations, and its

individualization.
The results of the comparative analysis revealed significant differences between traditional and modern feedback systems. Traditional systems (e.g., verbal or written comments, manual recording) often have delays and subjectivity, which limit the ability of the user or learner to respond effectively. Modern digital systems, on the other hand, have the ability to provide real-time analysis, automatic evaluation , and personalized recommendations.[10] At the same time, modern systems are more likely to be accepted and effective because they focus on the user experience (UX) .
The study analyzed practical examples from various industries. For example, in the education sector, MOOC platforms (Coursera, edX) provide users with real-time test results and personalized recommendations. In manufacturing, feedback systems based on IoT sensors monitor equipment performance and signal maintenance before a failure occurs. In the service sector , AI models that analyze customer feedback allow companies to make quick decisions to optimize service quality. These cases show that the effectiveness of feedback systems depends on their technological foundation and the degree of adaptation to user needs.
Based on the results obtained, it can be noted that three main factors are crucial for the effective functioning of feedback systems: first, the accuracy and reliability of data collection; second, the speed and flexibility of the analysis process; third, the accuracy, clarity and motivational impact of the response delivered to the user. Together, these factors determine the effectiveness of the system.
The analysis showed that the main trends in the development of modern feedback systems are: first, expanding the possibilities of providing personalized and predictive feedback based on artificial intelligence; second, making interfaces more intuitive based on in-depth analysis of user experience; third, enriching system responses by combining multi-source data (multimodal feedback).[11] At the same time, data privacy and ethical issues remain relevant, since feedback systems often process personal and sensitive data.
The results of the study show that the theoretical foundations of feedback systems lie at the intersection of three main paradigms: the cybernetics paradigm (control and self-adaptation), the communication paradigm (two-way communication), and the pedagogical paradigm (improvement of the learning process). When these three paradigms are used in harmony with each other, feedback systems provide not only technical efficiency, but also adaptability to the human factor.
Of indicators was developed to assess the effectiveness of feedback systems . The following were included in this system: response speed, accuracy level, user satisfaction level, adaptation coefficient, error reduction index , and impact on the learning or work process. These indicators will serve as the basis for practical testing in further research.[12]
The final analysis shows that in the future, feedback systems will become more intelligent, flexible, and user-centric. This will expand their application not only in education and manufacturing, but also in healthcare, public administration, security, and many other areas. At the same time, along with technological development, the need to develop ethical standards and strategies to ensure data security will also increase.
In general, the results of this study serve to deepen the understanding of the theoretical foundations of feedback systems, expand their practical application, and create a scientific foundation for future scientific and technological developments. The conclusions obtained will allow us to make practical recommendations for creating more advanced, user-friendly, and information security-compliant systems in this area in the future.

CONCLUSION AND SUGGESTIONS

Deeply studied the theoretical foundations of feedback support systems, their formation, development trends and practical application. The results showed that feedback systems are considered not only an integral part of technological processes, but also an important

management mechanism that serves to increase efficiency in almost all areas of human activity.
During the study , the scientific basis of feedback systems was consistently analyzed based on the theories of cybernetics, communication and pedagogy. From the point of view of cybernetics, feedback is a central element of the control cycle , allowing the system to adapt itself, correct errors and optimize the direction towards achieving the goal. From the point of view of communication theory, feedback provides a two-way flow of information, establishing effective communication between the transmitter and the receiver. The pedagogical approach sees feedback as a means of personal development, self-control and improving the quality of the educational process.
The results show that modern feedback systems are fundamentally different from the classical model. While traditional systems have shortcomings such as latency, subjectivity , and lack of flexibility, modern systems have the ability to provide high-speed, accurate, and personalized responses through artificial intelligence, big data analytics, IoT technologies, and real-time monitoring. This is an important factor in improving the user experience and increasing system efficiency.
The analysis process showed that for feedback systems to work successfully, three main conditions must be met: accuracy and reliability of data collection, speed and flexibility of the analysis process, and clarity, clarity, and motivation of the response delivered to the user. These conditions are equally important in ensuring the technical and psychological effectiveness of the system.
The research provided examples from various fields: real-time test results and personalized recommendations on MOOC platforms in education; IoT sensor-based monitoring in manufacturing; and AI models analyzing customer feedback in service delivery. These examples confirm the universality of feedback systems and their effective application in various fields.
of indicators was developed for evaluating feedback systems : response speed, accuracy, user satisfaction, level of customization, error reduction index, and process impact. These indicators serve as a practical basis for further scientific research.
The analysis of future prospects identified the following trends: expanding the possibilities of providing predictive and personalized feedback based on artificial intelligence; making user interfaces intuitive and convenient; enriching system responses by integrating multimodal information sources; further strengthening data privacy and ethical issues. These directions will take the development of feedback systems to a new level.
As a final conclusion, it can be said that feedback systems are not just a technical tool, but a complex mechanism of human-system interaction , and for its successful operation, it is necessary to combine theoretical foundations, technological solutions and psychological approaches. The results obtained in the study create a scientific basis for further improving these systems, strengthening the user-centered approach and applying them in a wider range of areas. At the same time, taking strict measures to protect ethical standards, information security and user rights in the design and implementation of feedback systems will remain one of the urgent tasks in the future.
In general, the scientific and practical significance of this study is that it systematically covered the theoretical foundations of feedback systems, analyzed existing and promising technological approaches, and identified new questions and directions for future research. This can serve as an important guide not only for the scientific community, but also for practicing specialists.

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