POSSIBILITIES OF SCIENTIFIC SEARCH IN FORMING THE CREATIVITY OF A FUTURE ENGINEER

POSSIBILIDADES DE PESQUISA CIENTÍFICA NA FORMAÇÃO DA CRIATIVIDADE DE UM FUTURO ENGENHEIRO

POSIBILIDADES DE LA BÚSQUEDA CIENTÍFICA PARA FORMAR LA CREATIVIDAD DE UN FUTURO INGENIERO

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ABSTRACT: The purpose of the article: to determine the potential of scientific research in domestic and foreign professional education in the formation of the creativity of a future engineer. Research methods: theoretical analysis of foreign and domestic literature, conversations, analysis of questionnaires, personal experience, assessment and self-assessment of bachelors, generalization and systematization of the data obtained. Research results: the article presents a theoretical analysis and analysis of research results, which allows: to give a formulation and reveal the content of the concept of "scientific search", to define it as a significant side of the future engineer; identify mechanisms, models, principles and rules and types of scientific research etc. Conclusions: the possibilities of scientific research as a means of shaping the creativity of a future engineer have been determined, the importance of his/her motivational and reflexive position in engineering education has been substantiated.

KEYWORDS: Creativity. Engineering education. Reflection.

RESUMO: *O objetivo do artigo: determinar o potencial da pesquisa científica na formação profissional nacional e estrangeira na formação da criatividade de um futuro engenheiro. Métodos de investigação: análise teórica da literatura estrangeira e nacional, conversas, análise de questionários, experiência pessoal, avaliação e autoavaliação de licenciados, generalização e sistematização dos dados obtidos. Resultados da pesquisa: o artigo apresenta uma análise teórica e uma análise dos resultados da pesquisa, que permite: formular e revelar o conteúdo do conceito de "pesquisa científica", para defini-lo como uma face significativa do futuro engenheiro; identificar mecanismos, modelos, princípios e regras e tipos de pesquisa científica etc. Conclusões: foram determinadas as possibilidades da pesquisa científica como meio de moldar a criatividade de um futuro engenheiro, comprovada a importância de sua posição motivacional e reflexiva no ensino de engenharia.*

PALAVRAS-CHAVE: *Criatividade. Educação em engenharia. Reflexão.*

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***RESUMEN**: El propósito del artículo: determinar el potencial de la investigación científica en la educación profesional nacional y extranjera en la formación de la creatividad de un futuro ingeniero. Métodos de investigación: análisis teórico de la literatura extranjera y nacional, conversaciones, análisis de cuestionarios, experiencia personal, valoración y autoevaluación de licenciados, generalización y sistematización de los datos obtenidos. Resultados de la investigación: el artículo presenta un análisis teórico y análisis de los resultados de la investigación, que permite: dar una formulación y revelar el contenido del concepto de "búsqueda científica", definirlo como un lado significativo del futuro ingeniero; identificar mecanismos, modelos, principios y reglas y tipos de investigación científica, etc. Conclusiones: se han determinado las posibilidades de la investigación científica como medio para dar forma a la creatividad de un futuro ingeniero, se ha comprobado la importancia de su posición motivacional y reflexiva en la formación en ingeniería.*

***PALABRAS CLAVE**: Creatividad. Educación en ingeniería. Reflexión.*

Introduction

In modern conditions of the formation of a single world educational space, the main technical university is the high-quality training of future specialists who are able to independently put forward hypotheses, research, design, create, discover, in other words, who are able to organize and actively conduct an independent scientific search.

A new type of innovation in the economy requires specialists who have systemically organized, reflexive, self-organizing, creative principles that allow them to be successful in engineering. Creativity is an important factor in the professional development of a future engineer, which determines the ability to understand and overcome barriers to professional development, to find constructive ways out of professional crises (BUGAKOVA; MIROSHNIKOVA, 2019; LIEBERMAN, 2015; MIKHALEVA; SAYFUTDINOVA, 2021).

The creativity of an engineer is the inner potential of a future engineer, manifested in the ability to constructive, non-standard thinking, as well as consciousness, the development of his/her experience. It is creativity that ensures a stable transition to professional development and successful self-realization.

According to our research, scientific survey provides an opportunity for the formation of creativity of the subjects of the educational process in the field of engineering education. Creativity is formed by introducing a student of an engineering university into scientific and creative activity, which is subject to change in the context of increasing the share of the educational program through creative technologies, competitions, project activities, and that allows students to deepen their knowledge and apply it in life.

Scientific research teaches, develops imagination, brings creative ideas into reality. That is why it can lead to success in meeting the social needs of society. To successfully conduct a scientific search, it is necessary to have internal motivation and abilities, called a research potential by N.V. Bodrovskaya.

The motivational component of scientific research potential implies:

• focus on novelty, intolerance to uncertainty (according to N. V. Bodrovskaya);

• "the joy of knowledge", intellectual curiosity, "so that the spark of God opens up in every person," according to V. A. Sukhomlinsky.

The behavioral component of research potential involves self-organization, self-development, and adaptability (BULTSEVA; LEBEDEVA, 2018; ROZHIK, 2018).

Theoretical analysis allows us to talk about the dependence of the level of realization of the potential of scientific search for future engineers from the time perspective, self-esteem, the level of emotional perception, originality, and self-confidence. Students with the above characteristics effectively conduct scientific research and achieve high results. Therefore, it is necessary to create appropriate pedagogical conditions to increase self-confidence, to create a favorable creative atmosphere, to increase the level of reflection in the process of scientific research (MOROZ, 2015; ZAKHAROVA; CHERKESOV; AKISHIN, 2016; BERNHARD, 2016).

Theoretical foundations of the research

"Scientific search as a means of shaping the creativity of a future engineer" is a paradoxical topic of pedagogical research. On the one hand, creativity, which is characterized by spontaneity, destruction of methodological canons; on the other hand, scientific search is not a chaotic action, but an intentional movement towards the goal, towards the solution of the assigned tasks.

Scientific search, in pedagogy, is revealed as: a teaching method (Y. I. Lerner, N. M. Skatkin); an element of creativity (A. P. Tryapitsyna); a mechanism of forming a creative attitude to activity (N. Gromova); an activity (S. A. Koval); a mechanism of creative productive activity, a mechanism of forming a value orientation (A. V. Kiryakova). In the concept of V. S. Rotenberg (2018) and V. V. Arshavsky, the search is determined by non-satiation and transfer from one type of activity to another.

Scientific search, in philosophy, is broadly defined as the process of actualizing the potential capabilities of the world around a person, as well as capabilities of a person and of

society as a whole. N. P. Chupakhin considers scientific search as a cultural phenomenon, and the culture of scientific search as a necessary component of the cultural world – a sphere created by mankind on the basis of the real world, consisting of organic and inorganic spheres.

In other words, the concept of scientific search, from the point of view of philosophy, reveals the problems of world perception, world outlook, the meaning of human existence, which emphasizes the relevance of the research topic.

We take the following working concept in our research: scientific search is a process of information retrieval according to the direction of research, that fixes the novelty and determines the result of scientific knowledge (LUCAS; HANSON, 2016; ROTENBERG, 2018).

Scientific search in our study is a means of shaping the creativity of a future specialist. From the point of view of philosophy, a means is an action correlated with the goal that is supposed to be achieved with the help of it.

The scientific search of a future engineer is interpreted as actualization of the potential capabilities of a future engineer to build a research process in the process of implementing professional activities.

The basics of scientific research, the sequence of stages, the logic of research constitute a methodological literacy, that is a set of methodological characteristics presented in a certain sequence.

A theoretical analysis of domestic and foreign experience makes it possible to single out the main models of scientific research:

• linear (problem statement, analysis, search, solution according to Bayer, Nelson, Feton and Joyce);

• structural and systemic (baseline analysis, decision plan, guess, final decision);

• abductive (according to Massmalas).

Let us dwell on the abductive model of scientific research by Ch. Pearce, which consists of two parts:

• abduction – the advancement, invention and generation of guesses, assumptions, hypotheses and theories.

• retrain – the verification of the hypotheses put forward by means of abduction (BULTSEVA; LEBEDEVA, 2018).

According to Ch. Pearce, scientific research is a creative process that requires not only logic, but also intuition and imagination. Thus, scientific search does not have a universal

algorithm, and abductive reasoning is just a scheme for testing hypotheses (BUGAKOVA; MIROSHNIKOVA, 2019).

The study of the phenomenon, the prospects for considering scientific research as a means of forming creativity is of great importance: scientific research significantly affects the increase in the level of semantic divergence, which contributes to the formation of students' creativity. There is a need to create search forms of student activity in the transition from a stereotypical broadcasting education to a relaying creative educational process that can create a new class of creative engineers. And this need becomes more and more urgent.

According to the results of the study by A. A. Derkach, E. A. Sigida on the development of creativity, the environmental direction of the study of creativity in the educational process required taking into account: the need-information aspect, which includes an analysis of the nature and content of general educational programs, and interpersonal interaction, that is, the system of emotional relationships that forms a creative climate in the educational environment (MIKHALEVA; SAYFUTDINOVA, 2021; YAKOVLEVA, 2017).

Among the mechanisms of the formation of creativity there is creative consciousness and creative interaction in the process of scientific research. Being non-standard, creative consciousness is characterized by the predominance of orientation towards research activities (BOSMAN; FERNHABER, 2016; LUCAS; HANSON, 2016; TRANQUILLO, 2017).

Theoretical and empirical analysis make it possible to single out the following pedagogical conditions that ensure creative interaction in the process of scientific research:

• Introduction of the future engineer into scientific research (formation of motivation for scientific research, enrichment of the experience of research activities, variability of methods for enhancing scientific research) (TORRANCE, 1963).

• Organization of scientific research in a creative-reflective environment, considering the interests of the future engineer (creating an atmosphere of psychological comfort, forming a map of the student's scientific interests) (GUILFORD, 1957).

• Implementation of scientific research results (creation of a card index of experimental activities, formation of a portfolio of scientific achievements, creation of a research media library) (MARQUIS, 2017; CRUZ; SAUNDERS-SMITS; GROEN, 2019).

Let us designate the functions of scientific research activity:

• Transformative – interpretation of facts in a new way, theoretical modeling (RAE; MELTON, 2017; BODEN, 1994).

• Technological – mastering the techniques of technological activities for design and engineering (STEGHÖFER, 2016).

• Program-targeted – the implementation of scientific research through goal-setting, forecasting, planning, organization (CHEVILLE, 2015).

• Control and regulatory – regulates the strategy of scientific research, including the act of decision-making, control and correction (DUNNE, 2017).

• Research – focuses on the analysis of the procedural and dynamic aspects of the surrounding world (MCCANTS, 2015).

• Creative – directs on the generation of new ideas, based on the analysis and systematization of the knowledge gained, determines all aspects of the creative development of the future engineer (MIKHALEVA; SAYFUTDINOVA, 2021; ROTENBERG, 2018).

The result of the professional development of future engineers is their ability to go beyond the continuous stream of everyday practice and see professional activity as a whole. This allows students to purposefully design a program for their self-development.

In our work, we posed the question of tracking the possibilities of scientific research, identifying the pros and cons of research activities in forming the creativity of a future engineer (WHEADON; DUVAL-COUETIL, 2017).

In the study the opportunity is interpreted as a set of means to achieve the goal.

The analysis of theoretical research and our own experience determined the choice of pedagogical possibilities of scientific research aimed at forming the creativity of the future engineer:

• orientation towards continuous self-education;

• self-presentation;

• variability, flexibility of the organizational structure of training;

• socialization of students in the process of teamwork in the scientific online community;

• possibility of providing an information and activity approach;

• possibility of intensifying the learning process.

Research methodology

The methodological basis of the work is the activity approach, comparative analysis of the results of individual conversations, portfolio analysis, questionnaires, the experience of the authors of the article, self-assessment, observations, systematization of the data obtained.

The research procedure required a theoretical analysis of foreign and domestic psychological and pedagogical works.

The selection of diagnostic tools was based on the analysis of the theoretical model of the activity of a modern engineer and self-learning student.

The main empirical research was carried out in the first, the second, the third and the fourth years of study of West Kazakhstan Agrarian Technical University and among the students of the International Educational Holding "GAUDEAMYS". 160 bachelors and 120 applicants participated in the survey. A delayed verification of the experimental results was carried out to clarify the representativeness of the sample (MIKHALEVA; SAYFUTDINOVA, 2021).

Research results

In our study, the formation of creativity of future engineers was carried out by acquainting students with the experience of scientific research.

The positive and negative effects of creative research activity were monitored. The work was aimed at self-development, self-realization, the formation of creativity of students. In the process of approbation of the selected ways of scientific research, the difficulties that the future engineer faces in the process of their implementation were highlighted.

At the final stage of the transformation of existing experience, reflection of the novelty and originality of the solution of the most complex and urgent problems, the criteria for evaluating the results of scientific engineering search were corrected; development of an idea in an applied aspect and its implementation in practice; determining the risks of introducing scientific research.

According to our research, possible risks of the scientific research activities of the future engineer have been identified:

• lack of integrity of the structure of scientific research;

• wrong choice of the object of research, complexity or ambiguity of the way of scientific research;

• inconsistency of the nature of scientific research with the declared pedagogical goals;

• the desire to conduct scientific research, limited to a certain resource, and not to seek or create new ones;

• the utopian nature of research;

• possibility of negative consequences as a result of the implementation of the fruits of scientific research of the future engineer;

• lack of moral preparation of research subjects for the necessary changes.

When designing the inclusion of the future engineer in the process of implementing scientific research, we considered the level of development of the intellectual abilities of the future engineer (this allowed students to timely master the technical, economic, and cultural changes in society) as well as the degree of initiative, readiness to work in modern conditions.

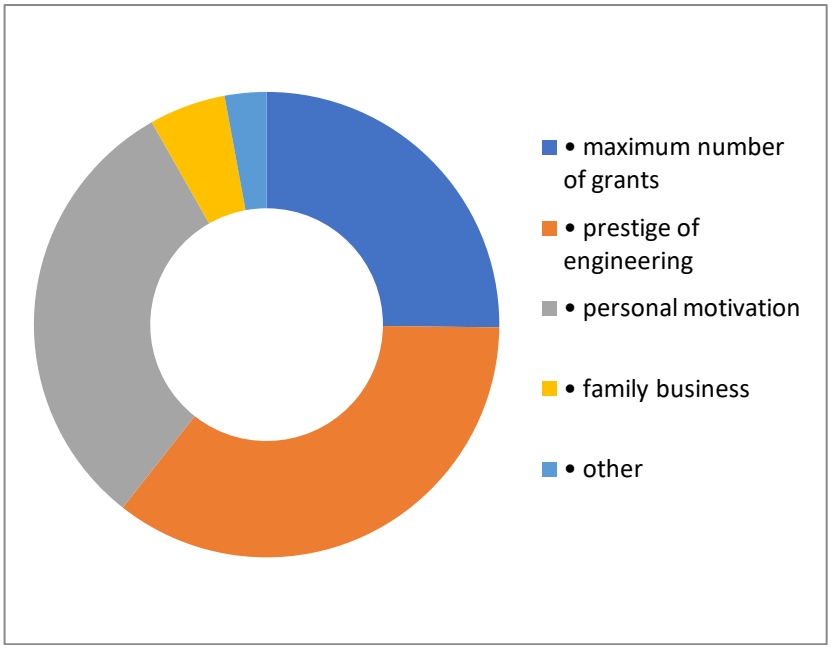
We have compiled an individual map of scientific interests, which determines the direction of students' scientific search on an individual basis.

Each student from the first year of study forms a portfolio of scientific achievements, which reflects the result of the implementation of his/her personal abilities, the manifestation of talents and the original concept of engineering experience in solving problems, unforeseen situations. This provides a greater degree of preparedness with significant market responsibility.

On the elective course "Theory and Practice of Scientific Research" during questioning, interviews, it was revealed that as a reason for choosing an engineering specialty, students single out: (Fig. 1)

- the maximum number of grants for technical specialties – 37.4%;
- prestige of engineering – 52.6%;
- personal motivation – 46.3%;
- family business – 7.9%;
- other – 4.3%.

Figure 1 – Diagram showing the reasons for choosing an engineering profession



Source: Devised by the author

To the question "Should a future student be creative?" 84% of 120 respondents answered positively.

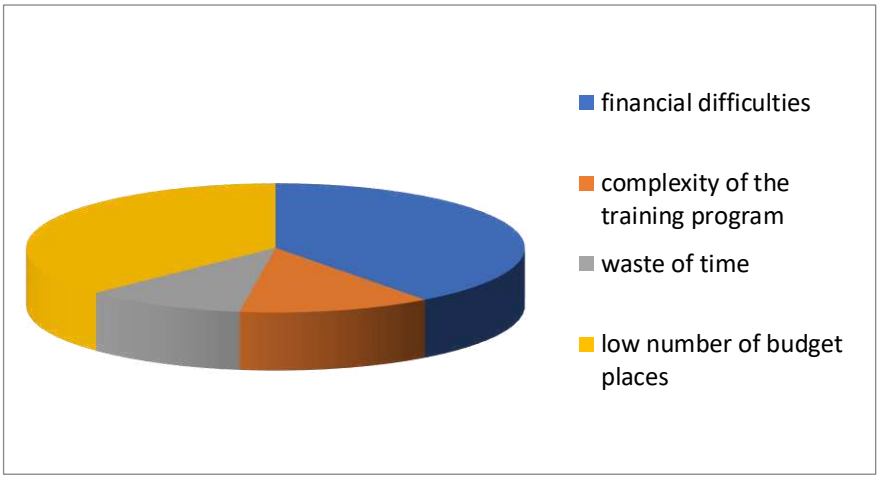
Observing the attitude of third-year bachelors to the profession in practice, during conversations, made it possible to reveal that future engineers had difficulty in carrying out independent scientific research without a program of additional training for its implementation. The inclusion of future engineers in the online scientific community provided an opportunity for the exchange of experience and contributed to a more effective implementation of scientific research and the implementation of tasks.

According to the results of the survey of first-year engineering students, 5.3% expressed a desire to continue their studies to get master's degree. The implementation of the program for the formation of creativity of the future engineer contributed to an increase in this indicator to 46.7%.

To the question "What difficulties do you have that messes you to get master's degree, with the aim of further continuing scientific research in the learning process?", according to the survey, a number of factors were identified:

- financial difficulties – 46.8%;
- complexity of the training program – 14.7%;
- waste of time – 12.3%;
- low number of budget places – 43.8%.

Figure 2 – Diagram of limiting factors in the implementation of scientific research associated with admission to the magistracy



Source: Devised by the authors

In the process of scientific research, bachelors mastered the ability to diagnose the level of their professional and creative abilities.

Independent research activities of future engineers ensured freedom and creativity, the ability to learn methods and techniques of effective professional and creative activity.

Answering the question "What role does scientific research play in the life of a future engineer?" bachelors noted that this is the main indicator of a person's scientific and creative activity, the boundaries of his/her responsibility, a guideline for personal development (BULTSEVA; LEBEDEVA, 2018, p. 9).

As a reason for refusing scientific research, the respondents noted:

• fear of failure – 26.3%;

• laziness – 12.3%

• lack of information regarding the methodology of scientific research – 23,4%;

• plagiarism of scientific ideas – 48.9%.

The results of the survey emphasize the relevance of creating and implementing additional programs that fill the gaps in knowledge in the theory and practice of implementing the scientific search for a future engineer and eliminate fears in the context of this issue. Almost half of the respondents refuse to participate in scientific research and to publish their scientific business ideas as a result of the negative experience of the respondents on deprivation of copyright to their invention, through the widespread practice of plagiarizing scientific ideas and appropriating their ideas by organizers of scientific youth projects for the purpose of subsequent funding. This is a serious issue that requires a rethinking of the rules and guarantees for organizing research projects with grant funding, attracting young specialists to participate.

The results of self-diagnostics allow us to note that if in the first year bachelors in most cases were diagnosed passive-negative (14.1%) and formally-performing (44.3%), then at the end of the fourth year they were dominated by reproductive (11.3%) and productive (67.7%) research styles. 71% of the respondents were able to identify the reasons for the difficulties in their activities by the final year.

In the course of individual conversations with teachers, analysis of the portfolio of scientific achievements, future engineers drew conclusions about the level of their readiness for professional activity. That is, they predicted the effectiveness of their creativity, developed recommendations, and protected their image-projects.

A modern engineer is competent, mobile, communicative, creative and able to implement independently conduct scientific research, introduce innovations and show high-quality results.

In the process of implementing scientific research, the following skills are formed:

• independent research work,

• initiative and creativity,

• skill of teamwork,

• skill of working with scientific literature,

• skill of critical assessment and reflection,

• managerial skill – planning activities, time, forecasting the consequences.

However, independence in substantiating the choice of effective methods, techniques and means of scientific research and self-regulation of creative activity in preparation for scientific and creative activity 37.7% of bachelors manifested itself situationally, and it was observed as insufficiently stable at 15.9% of bachelors.

The results of the study show that there was not enough knowledge to solve emerging problems. Often, the intellect was blocked by emotional urges.

At the empirical stage, future engineers practiced teaching techniques: teaching students to work in small groups, aimed at organizing joint activities of students under the leadership of a tutor; methods of design technology (individual or collective activities of trainees for the selection, distribution and systematization of material according to the topic under study); case-study, which allows, during the analysis of real problem situations that took place in the course of pedagogical practice, to ensure the search and selection of optimal solutions for their solutions. The main diagnostic methods were solving situations, creative methods and techniques (“cross-sense”, “mind maps”, “original use”, “collective notebook”, “coup”, “analysis of the relevance tree”, “cause-and-effect diagram”, etc.).

Conclusion

It was revealed that creativity of the future engineer is successfully realized if we: encourage students to scientific research; provide mechanisms to mobilize resources around students' ideas; equally accept small changes and new ideas on a large scale.

The question of supplementing the variable part of educational programs with courses aimed at shaping the creativity of future engineers and the practice of scientific research also requires rethinking.

A modern engineer is a self-learning student, primarily because he/she has the right to independently set learning goals, determine the pace, educational resources, experiences, requests for new personalized educational forms and technologies. That is, a personal style of

cognition becomes characteristic of a modern student in the process of scientific search for the information he needs. This means that the ability to reflect on the facts obtained, highlight the information that interested him, analyze it, pose clarifying, replenishing questions allow a student to purposefully systematize, generalize and personally interpret the information received. This is facilitated by the creativity of modern students, their readiness to analyze, to solve and perform various problematic tasks with a partner in the process of scientific research.

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How to reference this article

SAIFUTDINOVA, G. S. Possibilities of scientific search in forming the creativity of a future engineer. **Revista on line de Política e Gestão Educacional**, Araraquara, v. 25, n. esp. 5, p. 3232-3245, Dec. 2021. e-ISSN: 1519-9029. DOI: https://doi.org/10.22633/rpge.v25iesp.5.16011

Submitted: 13/03/2021
Required revisions: 23/07/2021
Approved: 19/11/2021
Published: 30/12/2021

Processing and editing by Editora Ibero-Americana de Educação - EIAE.
Correction, formating, standardization and translation.