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THE ROLE OF SCIENTIFIC SCHOOLS IN SHAPING THE INTELLECTUAL INFRASTRUCTURE OF A UNIVERSITY

O PAPEL DAS ESCOLAS CIENTÍFICAS NA FORMAÇÃO DA INFRAESTRUTURA INTELECTUAL DE UMA UNIVERSIDADE

EL PAPEL DE LAS ESCUELAS CIENTÍFICAS EN LA CONFIGURACIÓN DE LA INFRAESTRUCTURA INTELECTUAL DE UNA UNIVERSIDAD

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ABSTRACT: The aim of this article is to analyze the role of scientific schools in shaping the intellectual infrastructure of a university. The methods by which scientific schools influence the development of intellectual infrastructure within universities are explored. The study identifies the main markers influencing the dynamics of university intellectual infrastructure, including structuring the scientific school; the leader and team of the school; scientific publications and editions; citation of works by scientific school members; and participation of members in various high-quality national and international scientific activities. Special attention is given to the functioning of scientific schools in the university environment, particularly in shaping modern educational programs. Additionally, the significant role of scientific schools in engaging interested students in research, addressing the practical needs of the educational process, expanding the university's opportunities for external—especially international—collaboration, and contributing to the development of socially oriented education systems is highlighted.

KEYWORDS: Scientific school. Intellectual infrastructure. University intellectual infrastructure. Activity markers of the scientific school.

RESUMO*: O objetivo deste artigo é analisar o papel das escolas científicas na formação da infraestrutura intelectual de uma universidade. São explorados os métodos pelos quais as escolas científicas influenciam o desenvolvimento da infraestrutura intelectual nas universidades. O estudo identifica os principais marcadores que influenciam a dinâmica da infraestrutura intelectual universitária, incluindo: a estruturação da escola científica; o líder e a equipe da escola; as publicações e edições científicas; a citação dos trabalhos dos membros da escola científica; a participação dos membros em diversas atividades científicas nacionais e internacionais de alta qualidade. É dada atenção especial ao funcionamento das escolas científicas no ambiente universitário, particularmente na formação de programas educacionais modernos. Além disso, destaca-se o papel significativo das escolas científicas no envolvimento de estudantes interessados na pesquisa, no atendimento às necessidades práticas do processo educacional, na ampliação das oportunidades da universidade para colaboração externa, especialmente internacional, e na contribuição para o desenvolvimento de sistemas educacionais voltados para o social.*

PALAVRAS-CHAVE*: Escola científica. Infraestrutura intelectual. Infraestrutura intelectual universitária. Marcadores de atividade da escola científica.*

RESUMEN*: El objetivo de este artículo es analizar el papel de las escuelas científicas en la configuración de la infraestructura intelectual de una universidad. Se exploran los métodos mediante los cuales las escuelas científicas influyen en el desarrollo de la infraestructura intelectual dentro de las universidades. El estudio identifica los principales marcadores que influyen en la dinámica de la infraestructura intelectual universitaria, incluyendo: la estructuración de la escuela científica; el líder y el equipo de la escuela; las publicaciones científicas y ediciones; la citación de los trabajos de los miembros de la escuela científica; la participación de los miembros en diversas actividades científicas nacionales e internacionales de alta calidad. Se presta especial atención al funcionamiento de las escuelas científicas en el entorno universitario, particularmente en la configuración de los programas educativos modernos. Además, se destaca el papel significativo de las escuelas científicas en la implicación de los estudiantes interesados en la investigación, la atención a las necesidades prácticas del proceso educativo, la ampliación de las oportunidades de la universidad para la* *colaboración externa, especialmente internacional, y la contribución al desarrollo de sistemas educativos orientados a lo social.*

PALABRAS CLAVE*: Escuela científica. Infraestructura intelectual. Infraestructura intelectual universitaria. Marcadores de la actividad de las escuelas científicas.*

Introduction

Science, in its functional sense, represents a highly organized form of social activity. To conduct scientific work, researchers organize themselves into various types of communities based on different principles; these communities form both formal and informal networks. Informal communities, which play a crucial role in scientific development, as evidenced by the history of science, include, among others, scientific schools (Ustyuzhanina; Evsyukov, 2010). A scientific school is a community of researchers that emerges spontaneously and informally, meaning its creation cannot be declared or mandated, and it holds significant importance for the advancement of science (Vladimirov, 2013). Although scientific schools are primarily established to address specific research tasks and problems, they are often considered sociological and psychological phenomena rather than strictly methodological aspects of science (Kvanina, 2016). Nonetheless, the active functioning of scientific schools enhances the efficiency of the educational process, fosters a high-quality intellectual atmosphere within the university, and improves the prospects for international collaboration (Kozlov, 2015). To effectively address this issue, it is necessary to define two key concepts: “scientific school” and “intellectual infrastructure.”

To avoid excessive abstraction, intellectual infrastructure in the university context can be operationalized through observable indicators such as the number of active student research groups, the inclusion of research modules in curricula, and the volume of interdisciplinary educational projects. These measurable elements make the concept more transparent and demonstrate its practical implications for educational quality and student outcomes.

Literature review

As a rule, the term “scientific school” refers to a creative team of researchers from different generations working under the leadership of a recognized leader or continuing to develop the ideas initiated by that leader (Parakhonsky, 2007). Traditionally, the concept of a scientific school is primarily associated with the social sciences and humanities (Zacharchuk, 2011), such as the Frankfurt School of Philosophy, the Toledo School of Translation in philology, or the Vienna School of Fine Arts. However, this does not imply that natural and exact sciences lack these trends; examples include Niels Bohr’s Copenhagen School of Physics.

According to Zacharchuk (2012), a scientific school is a fellowship of individuals shaped under the aegis of a scholar or leader with specific ideas and topics for development.

The best schools are characterized by followers actively engaging in research within relevant fields, unified by shared ideas, methodologies, scientific traditions, expanding collaboration, and the pursuit of new facts (Krasikova, 2018). In a scientific school, hypotheses, concepts, and theories are proposed; debates and opposition are welcomed; and continuous brainstorming among its informal community members occurs. Members of a scientific school participate voluntarily rather than under obligation (Ustyuzhanina *et al*., 2011). Researchers argue that true scientific schools do not require external regulations (e.g., university council decisions on establishing and defining their activities). Their success entirely depends on internal self-organization and the potential of their leader and members (Klochkov; Panin, 2011).

The naming of scientific schools occurs in various ways. European examples include:

a) Naming after the city of origin (e.g., the aforementioned Frankfurt, Vienna, or Toledo Schools);

b) Naming after the cities hosting the universities where the schools operate (e.g., the Leipzig and Tübingen Schools in Germany, or the Paris and Lille Schools in France);

c) Naming after the founder or leader (e.g., the Kurchatov Scientific School) (Zakrevskaya, 2013).

In this context, researchers emphasize two key aspects: the locations of universities where these schools operate and the personalities, typically associated with these universities or specific academic units (Gavrilova, 2017).

Regarding the concept of "intellectual infrastructure," definitions generally focus on "the basic systems and services necessary for the efficient functioning of a company or industry" (Sekera, 2016, p. 93). In other studies, "intellectual infrastructure" is presented as "research infrastructure" (Yakovleva; Miller, 2021). In Leventsov *et al*. (2023), the components of intellectual infrastructure are identified as knowledge, professional skills, and abilities required for the successful functioning of businesses and organizations.

In this context, it is essential to note that the three main functions of a university—as a type of business and organization (conducting research, organizing educational processes, and providing services)—incorporate activities related to building its intellectual infrastructure. There is a growing focus on refining the concept of "intellectual infrastructure" to identify sources of its dynamism, optimize its interpretation, and transform it into an effective tool for achieving goals in various spheres of social activity. This trajectory often explores nontraditional perspectives (e.g., environment and intellect) rather than the more conventional (e.g., communications and transportation) understanding of infrastructure. Currently, much of this exploration focuses on information and organizational management (Leventsov *et al.*, 2023; Yakovleva; Miller, 2021).

Brett Frischmann (2012, p. 255) emphasizes that

> intellectual infrastructure, through fundamental research, ideas, general-purpose technologies, and languages, creates societal advantages by fostering a broad spectrum of productive activities, including information production, innovation, the development of products and services, education, socialization, and many other socially valuable activities.

Indian researchers A. Tiwari and U. Varadarajan (2018) argue that “the need for intellectual infrastructure in any organization arises when traditional organizational techniques fail to achieve results” (p. 34). This highlights the significant role of intellectual infrastructure in improving the quality of university education, with scientific schools serving as a key tool in this process.

In this study, the authors define “university intellectual infrastructure” as the scientific and cultural environment within a university, where the actors include students, researchers, faculty, and auxiliary academic staff.

The role of intellectual infrastructure is to accumulate social and cultural capital, which should serve the development of individuals and society (Efremova, 2018). The efficiency of this accumulation depends on several factors, primarily the quality of interaction between students and educators, the competence of auxiliary staff, management quality, and, crucially, the quality of those conducting research. This is because the structuring trend of a university’s success in the modern world is education built on research results, equipping students with the academic and professional knowledge necessary to be critical, analytical, and creative, enabling them to become key players in knowledge transformation and innovation across all societal sectors (Efimov; Lapteva, 2020).

Research, above all, should ensure socially oriented learning, contextual education, intercultural education, creative thinking, lifelong learning, and international cooperation (Mayer, 2021), including the synchronization of universities’ intellectual infrastructure development.

Thus, the purpose of this article is to analyze the roles of scientific schools in shaping the intellectual infrastructure of a university.

Methods and materials

In line with the outlined approaches to the role of scientific schools in shaping the intellectual infrastructure of a university, a qualitative-quantitative research methodology was adopted. Although the study relied primarily on expert evaluation, further research should include quantifiable data such as the number of publications per scientific school, participation rates of students in research projects, and the frequency of international collaborations. These metrics would allow comparisons across institutions and provide objective benchmarks for assessing the impact of scientific schools on educational development.

The study was conducted through an analysis of scientific literature on the chosen topic and an expert survey. The research aimed to summarize findings related to specific research questions, namely:

1. What are the key factors for the creation and functioning of a scientific school?
2. Which markers of scientific school activities stimulate the dynamics of a university's intellectual infrastructure?

Stage 1: Selection of Information Sources

In the initial phase of the study, relevant information sources necessary to achieve the research goals were selected. Data for this research were drawn from articles and reviews published in scientific journals indexed in Scopus and Web of Science. The search was conducted using keywords and phrases such as "scientific school," "intellectual infrastructure," and "university intellectual infrastructure" in both English and Russian.

Stage 2: Analysis of Selected Literature

Based on the analysis of the selected scientific literature, key factors for the creation and functioning of scientific schools were identified, as well as markers of their activities that stimulate the dynamics of a university's intellectual infrastructure.

Stage 3: Expert Survey

An expert survey was conducted to evaluate the significance of the markers identified in the second stage. The sample size of 43 experts was deemed sufficient for the research purposes. Invitations to participate in the survey were sent via email. The selection criterion for experts was the presence of at least three publications on the research topic in peer-reviewed journals. Of the 43 experts invited, 40 agreed to participate. Based on their responses, rankings and weights were assigned to the markers of scientific school activities, with the final values reflecting their significance from an expert perspective.

To ensure a more objective analysis of the data obtained through the expert survey, the degree of consensus among expert opinions was measured, and the results were mathematically processed using Kendall's coefficient of concordance.

Results

The analysis of scientific research identified key factors for the creation and functioning of a scientific school (Table 1).

Table 1 – Key factors for the creation and functioning of a scientific school

No.	Factors	Characteristics
1	Relationships between the founder and followers/students	Typically, the founder of a school is a scientist whose personality combines recognized scientific authority with organizational skills. These qualities enable the creation of optimal working conditions for school members through effective research management, removing bureaucratic and financial barriers, and shaping a framework of substantive and methodological views
2	Sense of unity and separation from representatives of other fields in the discipline	This factor motivates the joint execution of research and organizational tasks due to: (1) shared professional education under the founder's mentorship; (2) the influence and acceptance of a common set of "central ideas" dominant in the school, the use of shared literature, and a focus on the same research subject, leading to a unified understanding of the subject and a shared hierarchy of scientific values; (3) participation in the same conferences, co-authoring papers, publishing in the same journals, mutual citations, and involvement in scientific and public discussions.
3	Shared ideological core underpinning theoretical principles	(1) Adoption of specific scientific laws; (2) metaphysical concepts about the existence and nature of the objects studied (e.g., force fields, atoms, species, historical laws); (3) a shared belief in the evaluative role of models in research, which helps assess solutions and perform heuristic functions.

4	Common methodological assumptions	(1) Accepted theoretical values such as precision, simplicity, consistency, and utility; (2) preferred models and solutions, representing paradigms favored by the school, aimed at expanding paradigm-based decisions; (3) dissemination of exemplary paradigmatic solutions, fostering efficient research and the establishment of an ideology that newcomers must embrace to join the school; (4) acceptance of criteria for evaluating solutions to formulated problems. These criteria represent exemplary solutions within the school.
5	Additional factors	(1) Ability to publish a dedicated journal reflecting the school's ideological and methodological principles; (2) use of specific terminology or a distinct style; (3) shared worldview values among school members, such as pacifism, liberalism, or anti-irrationalism.

Source: Developed by the authors.

The analysis also identified key markers of scientific school activities that stimulate the positive dynamics of a university's intellectual infrastructure (Table 2), and the results of the expert survey helped rank and weigh these markers.

Table 2 – Key markers of scientific school activities stimulating positive dynamics in the intellectual infrastructure of a university

No.	Markers of Scientific School Activity	Rank	Weight
1	Structuring of the scientific school	2	0.22
2	The leader and the school's team	3	0.20
3	Scientific publications and editions, as well as dissertation defenses on the school's topics	4	0.14
4	Participation of school members in various high-quality national and international scientific activities	5	0.09
5	Recognition of the school by the surrounding scientific community	1	0.35

Source: Developed by the authors. Note: Compiled based on the expert survey; the Kendall's coefficient of concordance W = 0,74 ($p < 0.01$) indicates strong consensus among the experts.

Discussion

The primary agent markers influencing the dynamics of a university's intellectual infrastructure include (see Table 2): structuring the scientific school; the leader and the school's team; scientific publications and editions; citation of works by the school's members; participation of the school's members in various high-quality national and international scientific activities; and recognition of the school by the broader scientific community. This recognition encompasses the independent implementation of scientific projects by the school's members and the dissemination of their results outside the school's immediate activities (e.g., at conferences, roundtables, seminars, and discussions), invitations to participate in projects led by researchers from other academic institutions, citation of the school's members' works, and the defense of dissertations on topics relevant to the school.

In addition to qualitative markers, the introduction of quantitative indicators, such as student involvement rates, graduate research productivity, and international co-authorship, would make it possible to monitor the educational effectiveness of scientific schools over time. Such data could support more rigorous comparisons between universities and provide clearer evidence of the schools' contribution to intellectual infrastructure.

A key component underlying the influence of a scientific school on the dynamics of intellectual infrastructure is the structuring of the school. This does not refer to a fixed hierarchy but rather to the principles guiding its activities (Parakhonsky, 2007). These principles include the problem uniting the school's members; regular meetings addressing both organizational and strictly scientific issues; organization of conferences, symposiums, seminars, and discussions initiated by the school's leader or members; collaboration with domestic and international colleagues at both individual and collective levels; development of channels to integrate the school's work into broader scientific contexts; and incorporation of international experiences relevant to the school's interests. Another crucial element in structuring the school and extending its influence within the university's scientific and educational environment is involving students—either individually or through student scientific societies, which have become integral to the university's research landscape.

A well-structured approach to the scientific school's activities ensures effective task execution. For instance, during regular meetings, members can discuss research outcomes and develop new directions aligned with modern trends. Discussions at these meetings crystallize the research content, identify appropriate methodological approaches and methods (technologies), and outline proposals for implementing current and future results into practice. The exploratory nature of scientific research fosters critical thinking—not only in conducting research but also in critically evaluating its implementation (Frischmann, 2012).

The leader and the team of the scientific school form an organic unity that ensures the continuity of the research process and the application of its results. The leader inherently enriches the space of scientific ideas with elements essential for structuring the scientific school, including their generation and practical realization. Researchers believe that the leader of a scientific school must be an extroverted scientist. The extroverted nature of the school's leader and members is a necessary condition for the school's functioning. The stronger this characteristic, the longer the school's existence and, consequently, the longer its influence on the intellectualization of the university environment.

It is important for the leader of a scientific school to embody what is referred to in the global academic community as an "autonomous person"—an individual with a strong sense of identity and well-developed critical self-reflection (Klochkov; Panin, 2011). These two qualities drive the dynamics of a university's intellectual infrastructure. The first ensures "outreach," broadcasting the scientific school's achievements to a broader university audience, while the second serves as a "catalyst" for new (often original) ideas. The circulation of these ideas prompts the educational community to reflect on the intellectualization of the learning process, often leading to innovations.

Thanks to the scientific publications of scientific school members and the journals initiated by the school or those in which its representatives actively participate (e.g., through the publication of research results), scientific schools expand their influence on the dynamics of intellectual infrastructure. The practice of established scientific schools shows that their members strive to publish in high-quality outlets, such as journals with a high impact factor, particularly those indexed in internationally recognized scientific databases like Scopus, Web of Science, and Index Copernicus; in monographs based on representative international conferences; and in reference and encyclopedic publications acknowledged by professionals (Ustyuzhanina *et al*., 2011).

Another key component of the influence of a scientific school on the positive dynamics of a university's intellectual infrastructure is the participation of its members in various high-quality national and international scientific activities. This marker is significant not only for exchanging relevant information in a scientific sense but also for identifying opportunities to apply this information within university education systems. This approach aligns with the well-established practices of universities in most developed countries, where the educational process is primarily built on research conducted within the universities themselves. Scientific schools serve as innovative mobilizers for research topics and define the educational field. However, in certain cases (especially in pedagogical and literary-artistic universities), authorial schools may also act as mobilizers (Zacharchuk, 2012).

At the top of the pyramid of a scientific school's influence on the dynamics of intellectual infrastructure lies the recognition of the school by the broader scientific community. Evidence of this recognition includes the following markers:

- Independent implementation of scientific projects by the school's members and dissemination of results beyond the school's immediate activities (e.g., conferences, roundtables, seminars);
- Invitations for the school's members to participate in projects conducted by researchers from other academic institutions, including international collaborations;
- Citation of the scientific school's members' works in the scientific and educational community.

These markers signify the integration of a school's actors into global discourses on issues relevant to research groups worldwide. Furthermore, these activities often have interdisciplinary trends, increasing the chances of finding suitable answers to pressing questions in scientific and educational processes and addressing complex societal challenges. Consequently, the role of scientific schools in shaping and positively influencing the intellectual infrastructure of universities continues to grow.

It is worth noting that some researchers predict that academic disciplines will evolve into what is known as "post-academic science" (Mayer, 2021). This concept emphasizes the acquisition of interdisciplinary knowledge through collaboration among specialists from various fields (Zakrevskaya, 2013). A parallel trend gaining traction in the contemporary research community, which also provides new momentum to the development of scientific schools, is the use of crowdsourcing. According to a group of scientists practicing this approach, crowdsourcing can accelerate scientific progress and improve the quality of research (Efimov; Lapteva, 2020). Scientific schools are key mobilizers of such practices.

Over the past decade, several research teams have highlighted how structured crowdsourcing frameworks can meaningfully accelerate scientific progress and enhance research quality. For instance, Lenart-Gansiniec *et al.* (2023) conducted a comprehensive bibliometric analysis of crowdsourcing in science. They concluded that crowdsourcing complements traditional small-scale research by enabling large-scale data collection and distributed problem-solving capabilities, thereby catalyzing broader scientific inquiry with enhanced rigor and efficiency. Additionally, Watson and Floridi (2018) analyzed platforms like Zooniverse using empirical and Bayesian methods, demonstrating that their crowdsourced models substantially improve the scalability and reliability of data processing compared to conventional approaches.

These findings underscore the pivotal role of well-designed crowdsourced platforms in advancing research outcomes. For example, projects hosted on Zooniverse, such as Galaxy Zoo, have enabled volunteers to efficiently classify vast astronomical datasets, which in turn facilitated discoveries that would have been impractical through traditional expert-driven methods alone. Through these collaborative efforts, crowdsourcing not only accelerates the pace of data processing but also introduces diverse, independent contributions that improve data robustness and enrich research creativity.

Final considerations

In conclusion, the activities of scientific schools are intricately linked to the intellectual infrastructure of universities and influence its dynamics in several ways: they help identify research topics relevant to the educational process; actively attract interested parties from the faculty and student community to research; bring their activities closer to practical educational needs; and open opportunities for collaboration beyond the university, particularly in the realm of international cooperation, including the formation of socially oriented education systems.

Looking ahead, universities should consider developing clear policies that integrate the work of scientific schools into educational programs, for example, through research-based curricula, interdisciplinary student projects, and targeted support for international collaboration. Strengthening quantitative monitoring of scientific schools' outcomes would also provide more objective evidence of their impact on higher education quality. Moreover, future research should explore innovative practices such as digital platforms and crowdsourcing to broaden the schools' reach and adapt them to contemporary educational challenges. By doing so, scientific schools can evolve from being primarily research-driven communities into strategic engines of educational innovation and university development.

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