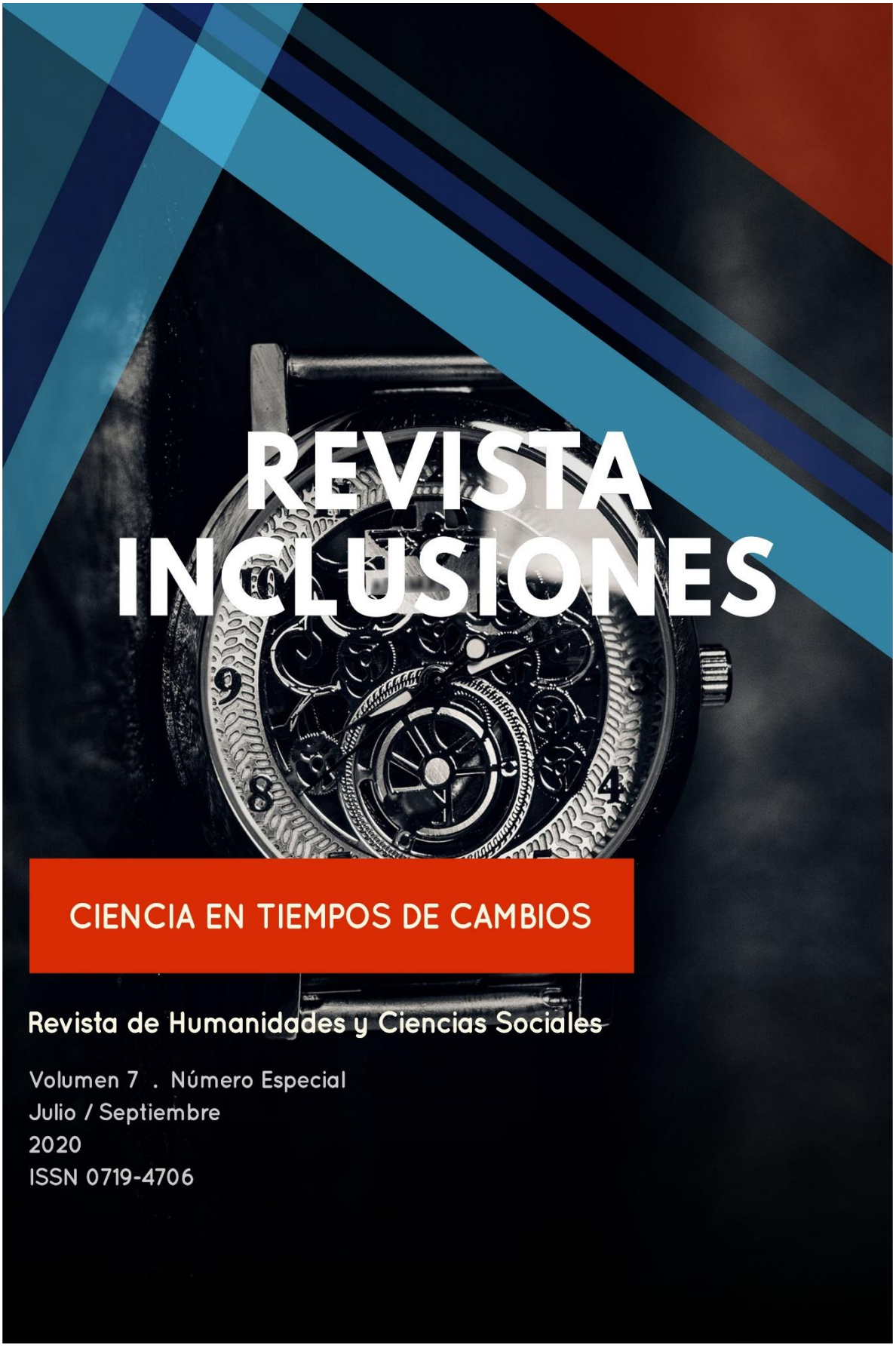

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RESEARCH MODELLING IN CIVIL ENGINEERING MASTER'S THESES

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Abstract

There are five consecutive stages identified in the Civil Engineering learning process (Vocational school or College programme, Bachelor's or Specialist's programme, Master's programme, Junior Doctorate or Junior Doctorate Military programme, Higher Doctorate programme). Each stage is completed with a qualifying parer that students or degree seekers must defended at public examinations. For the first two stages it is a diploma, and for the rest – a thesis. A transition to a subsequent educational stage envisages a higher level of theoretical development of the problem under study, independence in choosing research topic, justification of means and methods for solving research problems, and personal responsibility for the quality of the research results. Bachelor's programme is understood as an abridged version of traditionally existed Specialist's programme, and Master's programme is completely innovative for Russia. The ways of eliminating the educational lacuna of Master's programme in the Russian Federation have not yet been fully studied, the methodological approaches to the teaching technologies and to the form of completion of Master's programme remain controversial. Directive documents of the Ministry of Education name in parallel the student's final paper both "Master's thesis" (by analogy with foreign traditions) and "Graduation qualification work" (by analogy with the traditional practice of the national educational process).

Keywords

Stages of the educational process — Master's programme — Scientific and technical hypothesis

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Introduction

The educational disciplines of the Masters' programme at Architectural Technology and Construction Management Department of Moscow State University of Civil Engineering provide, inter alia, knowledge on reconstruction and redevelopment of urban areas and construction sites. The Master's programme envisages studying the main modern normative and directive documents[1], and rules of different sections of the construction industry. Master's students deepen their knowledge in the following fields:

- erection technologies of buildings and facilities[2] etc.;
- management of new construction projects and projects of reconstruction of existing buildings and facilities[3] etc.;
- management and planning in construction industry[4] etc.;
- renovation of urban areas, residential buildings and complexes[5], etc.;
- organizational and anthropotechnical reliability of functional systems of construction operations in mobile environment[6], etc.;
- complex multi-parameter evaluation of "man-technology-environment" systems based on comparison of their infographic models[7], etc.;
- other traditional and innovative aspects of modern construction industry.

The Civil Engineering Master's programme is a new phenomenon in the Russian education system. Methodology, technology and management of the processes, forms of thinking, and labour activities of university students and teaching staff, as well as communication, information, and energy processes of their joint productive activities are still at the stage of formation and adaptation.

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[1] Town-Planning Code of the Russian Federation, enacted by the Law of Russian Federation on 29 December 2004 No. 190-FZ, latest amendments enacted on Septemer 30, 2017. from http://www.consultant.ru/document/cons_doc_LAW_51040 (14.11.2017); SP 48.13330.2011 Code of Practice. Organization of Construction. Revised Edition of SNiP dated on January 12, 2004 (with Amendment No.1), from http://docs.cntd.ru/document/1200084098 (12.11.2017) y Standard Wage-Rates and Skills Reference Book (ETKS), 2017. from http://bizlog.ru/etks/.

[2] V. I. Telichenko and colleguaes. Erection Technology of Buildings and Facilities. A Textbook for Universities of Civil Engineering. 3rd Illustr. Edition (Moscow: Vysshaya Shkola Publ., 2006) y G. K. Sokolov, Construction Technology. 2nd Illustrated Edition (Moscow: Academia Publ., 2007).

[3] A. L. Shagin; L. B. Bondarenko; D. F. Goncharenko and V. B. Goncharov. Reconstruction of Buildings and Facilities. A Study Guide for Civil Engineering Universities (Moscow: Vysshaya Shkola Publ, 1991) y V. L. Zarenkov, Project Management: A Study Guide. 3rd Edition (St. Petersburg: SPbGASU Publ. 2010).

[4] L. G. Dikman, Construction Operations Management: A Textbook for Civil Engineering Universities. 6th Edition (Moscow: ABC Publ., 2009); B. F. Shirshikov, Management and Planning in Civil Engineering (Moscow: ABC Publ., 2012) y P. P. Oleynik, Fundamentals of Management in Civil Engineering. Part I, II (Moscow: ABC Publ. 2014).

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[6] V. O. Chulkov, Organizational and Anthropotechnical Reliability of Functional Systems of Construction Operations in Mobile Environment (Moscow: MGSU Publ., 2010) y V. O. Chulkov; R. R. Kazaryan R. R. and B. A. Levin, Organizational and Anthropotechnical Reliability of Functional Systems of Construction Operations in Mobile Environment: A Study Guid. 1st Edition (Moscow: MGUPS Publ., 2017).

[7] V. O. Chulkov and colleguaes, “Complex Multi-parameter Evaluation of "Man-Technology-Environment", Systems Based on Comparison of Their Infographic Models”, Mir Nauki Journal num 1 (2013): 7.

The situation is exacerbated by the norm of directive documents allowing applicants with a non-core basic education to join the Civil Engineering Masters' programme.

Therefore, an express analysis of Russian and foreign organizational forms and instututions to implement Master's programmes in different fields of education (engineering, medicine, psychology, architecture, economics, etc.) has been carried out. Among the studied methodological and descriptive materials taken from journals and online social networks were publications of specialist from Russia[8], etc., Austria[9], the UK[10], Latvia[11], Lithuania[12], Norway[13], the USA[14], and a number of other countries[15].

The approved and enacted Federal State Educational Standards of Higher Vocational Education[16] were also studied.

Materials and Methods

A master's thesis (graduate qualification work, graduation thesis) should be distinguished from a bachelor's degree by fundamental character, in-depth theoretical development of identified problem, independent choice of topic, goals and the tasks to be accomplished and the expected results, application of profound and specialized knowledge, justified choice of theories and methods used in solving research problems.

The ways of eliminating the educational lacuna of Master's programme in the Russian Federation have not yet been fully studied, making controversial the relevant methodological approaches to the teaching technologies.

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[8] L. V. Borisova and N. A. Vinogradova. Summary, Report, Thesis (Moscow: Academia Publ., 2012), from http://academiamoscow.ru/ftp_share/_books/fragments/fragment_18262.pdf; O. V. Uvarovskaya and I. U. Kraev, Independent Work of Students: A Teaching Aid (Syktyvkar: Syktyvkar GU Publ., 2009) from www.syktsu.ru/.../Metodicheskie-rekomendacii-po-samostrabote-uchash (11.11.2017); P. V. Zelenikhin, Rules for Preparation of Theses. A Study Guide (Kazan: 2014) y What is a Master's degree? Your Right Choise. From www.topuniversities.com/blog/what-masters-degree (11.11.2017).

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[11] T. Bulajeva; D. Lepaitė and D. Šileikaitė-Kaishauri, Degree Programme Development. Metodologial Guide for Study Programme Teachers (Vilniaus universitetas, 2012), from http://www4066.vu.lt/Files/File/02_Degree_programme_development.pdf (12.12.2017).

[12] Metodological Guidelimes For Writing And Defending Independent And Research Papers Approved at BA School of Business and Finance. Dean of Studies’ meeting on study and methodological issues on September 30, 2013, Minutes No 9, (Riga, 2013), 49, from http://www.ba.lv/wp-content/uploads/2014/10/METHODOLOGICAL-GUIDELINES-2013.pdf (12.12.2017).

[13] What will I learn? Master's Degree in Molecular Biosciences. University of Oslo. from https://www.hotcoursesabroad.com/study/course/norway/master-s-degree-molecular-biosciences-physiology-option/56352542/program.html (04.12.2017).

[14] Qualifying Process FAQs. Program Handbook - School Psychology, Taxes State University, Austin. Available from https://wikis.utexas.edu/display/edp/Qualifying+Process+FAQs (15.12.2017).

[15] Russian Federal Standards of Higher Education, from http://www.tusur.ru/en/education/documents/federal/gos/index.html (14.12. 2017).

[16] “Academic degree”, from http://en.academic.ru/dic.nsf/enwiki/113294 (09.12.2017).

As an example, consider an important and responsible procedure – choosing and approval of the topic of graduation thesis, which takes place during the first semester in the first year of learning (at the very beginning of master's programme).

Those who entered Master's programmes rarely imagine why they did this and what kind of learning they will have. Most of them are Bachelors who have just graduated from the university, and who sincerely consider that Master's programme as a continuation of the Bachelor's programme (that is, they are ready to implement the style and requirements of the previous stage of the educational process). However, each next stage of the educational process presupposes a higher level of fundamentality, theoretical development of research problem, justification of means and methods used in solving research problems.

The procedure of choosing a Master's graduation thesis has two variants: formal and substantial.

In the first variant, a research supervisor assigns a research topic to a Master's student, proposing to the student to choose it from the list of recommended topics approved at the meeting of the department. For Civil Engineering Masters' students such topics traditionally concern construction and redevelopment organization, technology, planning and management in construction projects[17].

The procedure is quite democratic (s/he chose it himself!) and convenient from an administrative viewpoint (by the date stated, in the list approved at the department meeting, research topics will be assigned). It is simpler initially, but more difficult both for research supervisors (who determine, instead of students, essence of scientific researches) and for Master's students (how to apply scientific knowledge in relation to assigned research topic). Therefore, the Procrustean bed of a beautiful topic is filled with other people's ideas, usually taken from a social network or literary sources.

In the second variant, a Master's student can and should reasonably choose her/his research topic, which is understandable and interested for her/him, and s/he will be able to take responsibility for the results of the relevant research by defending her/his thesis. The second variant initially imposes high demands on title seekers' erudition, their self-organization and responsibility skills (which, of course, are rare in our time), but gives them real opportunities to develop themselves to become scientists. This variant allows executing a research project as a logical result of a responsible structural and analytical approach to a real scientific research.

Nowadays, a directive variant of assignment of research topics for Master's theses prevails.
Reforms and experiments at different stages of the educational process in Russia will be surprising and puzzling us for a long time.

But a reforms' objectives are not only limited to achievements of something new, capable to transform activities and improve them (in terms of emergence of a new criterion or a group of criteria). They inevitably lead to elimination of old stereotypes, denial of existing achievements (since they meet the criterio that are now rejected); cancellation of

[17] Town-Planning Code of the Russian Federation, enacted by the Law of Russian Federation on 29 December 2004 No. 190-FZ, latest amendments enacted on Septemer 30, 2017. from http://www.consultant.ru/document/cons_doc_LAW_51040 (14.11.2017).

representations and organizational and technological algorithms in the minds of senior executives. If a change occurs gradually, it unobtrusively forms in the minds of merited scientists the need to change attitudes to pre-existing criteria and providing an opportunity to adapt to new criteria of activity, – there is at least a hope that it will be possible to implement this transition with the least moral, ethical, and physiological losses for people , participating in professional activities.

Authors of ideas and technologies of changes, and implementers of these changes, rarely resort to gradual implementation of their plans. They want to reach the target as soon as possible, to see immediately the expected results of the change process, and therefore, they do not even think about destruction of the old, and about social and physiological price of the destruction, they produce. Such changes "in the style of defeat" are extremely stringent. An example is the transition from a Bachelor' to a Master's programme.

There is no special scientific training for a bachelor. On entering to a Master's programme, s/he does not immediately understand that s/he has come into learning institution for assistant scientists. Therefore, from "Fundamentals of Professional Activities" training course he must understand what is science, scientific research, scientific modelling, scientific experiment, and scientific result.

Results

Masters learn that the social institute of science is a part of spiritual culture of society and the field of activity that is aimed at identifying, analysing and systematizing the objective knowledge of reality.

Science has many merits[18], etc. because it has the following characteristics: *generally acknowledged* (knowledge is suitable for all mankind), *reliable* (its conclusions are permissible and practically tested), *critical* (its basic conclusions can be revised demonstratively), *fragmentary* (it studies various fragments of reality and subdivided into into separate sections and disciplines), *dynamic* (provides increments of new knowledge and develops many types of human activity), *diverse* (expresses scientific knowledge in different forms: categories, laws, hypotheses, theories, scientific representation of the world, etc.).

Scientific activities are based on collections of phenomena and their interpretations; constant updating and systematization of the phenomena; critical analysis and synthesis of new knowledge or generalizations that not only describe natural or social phenomena, but also allow creating cause-effect relationships aiming at forecasting as the overall goal.
According to John M. Keynes, the fundamental concept of a science is a *hypothesis* that (if confirmed by practice) is formulated as a law of nature, society or thinking activity, which governs the following relevant kinds of *activities*:

[18] V. O. Chulkov; R. R. Kazaryan R. R. and B. A. Levin, Organizational and Anthropotechnical Reliability of Functional Systems of Construction Operations in Mobile Environment: A Study Guid. 1st Edition (Moscow: MGUPS Publ., 2017); V. O. Chulkov and colleguaes, “Complex Multi-parameter Evaluation of "Man-Technology-Environment" Systems Based on Comparison of Their Infographic Models”, Mir Nauki Journal num 1 (2013) y L. V. Borisova and N. A. Vinogradova, Summary, Report, Thesis (Moscow: Academia Publ., 2012), from http://academiamoscow.ru/ftp_share/_books/fragments/fragment_18262.pdf (11.11.2017).

positive science is a set of systematized knowledge about what exists in real life;
normative or *regulative science* is a set of systematized knowledge relating to what and how it should be, and therefore having their subject in something ideal, different from the real;
art is a system of rules to achieve a goal.

There are three meanings distinguished in the concept of science, etc.:

social institution (a set of scientists, scientific institutions and structures of scientific services), SI;
process (scientific activity), Pr;
result (a system of reliable scientific knowledge about nature, man and society), Re.

These meanings form a triad (Figure 1), in which monads (separate subjects of SI, Pr and Re) are distinguished, individual *action* of monads on each other (Figure 1 (a)) and composition of these influences (Figure 1 (b)), which can be replaced by a two-sided arrows (*interactions*) (Figure 1 (c)).

An interesting subject for a study in the SI-Pr-Re triad is the effect of a free monad on the interaction of two other monads of the triad, which is called loading (the bold arrows in Figure 1 (c)).

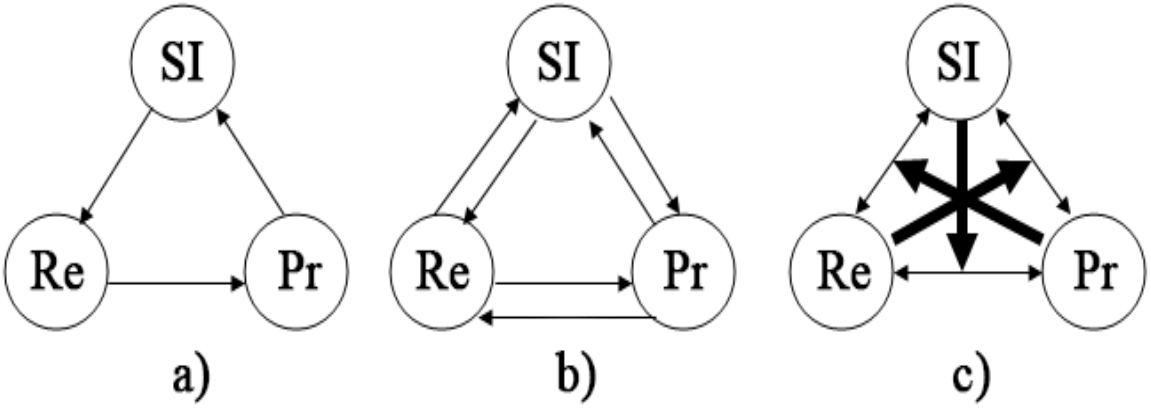

Figure 1
Actions, interactions and loadings in a SI-Pr-Re triad

Master must know how to use all these activity kinds and meanings, distinguishing a science from an art of achieving the result (craft) in her/his study. With regard to a research subject (object or process), Master's student must demonstrate his/her ability to successfully use the methods and means of both positive and normative science. Science is distinguished from any other sphere of human activity by its goals, means, motives and conditions in which scientific work proceeds. If the goal of science is comprehension of truth, then its method is *scientific research*.

Research, unlike spontaneous forms of cognition of the surrounding world, is based on the norm of scientific activity – *scientific method*, in the structure of which the "logistics vector of a scientific research" plays an important role (Figure 2).

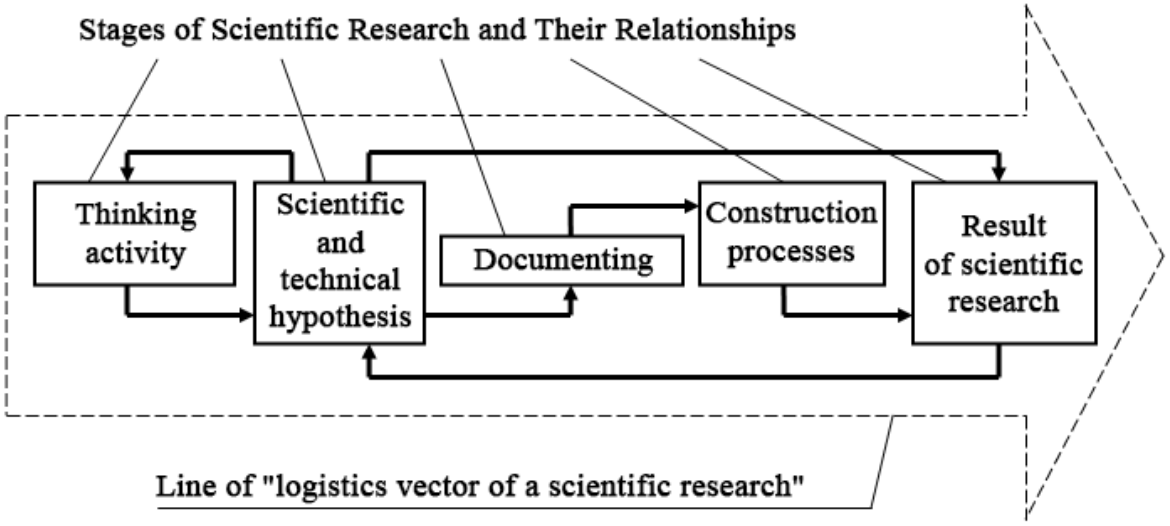

Figure 2
"Logistics vector of a scientific research" (sequence of activity stages and their interrelations in scientific research)

Discussion

The first principle of scientific research in civil engineering is a scientific and technical hypothesis – an initial explanation of a possible way of achieving the research objective. This is the main idea and the first step in solving a scientific problem that allows us to build a research cycle model, which can be the basis for clarifying or changing the scientific research procedure.

A scientific and technical hypothesis has a probabilistic nature; its validity must be confirmed and proved. If this can not be done, the scientific and technical hypothesis is recognized as erroneous and to be modified.

At the beginning of a scientific research, Master's student can put forward several hypotheses, the best of which will be determined by her/him in the process of multi-criteria evaluation of these alternatives.

The main phases of the methodology for developing scientific and technical hypothesis are the following:

1. Analysis of the state of science and practice in the field of forthcoming research (as a result, the research objective should be formulated).
2. Exploring possibilities of achieving this objective and factors that significantly influence the process to achieving it.
3. Identification of the most significant factors determining dynamics of research object (Master's research topic is formulated at this stage as an expected result of her/his scientific research).
4. Identification and systematization of cause-effect relationships of research object state (direction of scientific research is determined at this phase).
5. The choice of hypothesis representation form: textual, infographic model, matrix-based, diagrams or a combination of models, graphs and textual explanations, etc.

There are four stages of the scientific research cycle:

● development of a scientific and technical hypothesis;
● choice and evaluation of research methods and models;
● development of design considerations, organizational and technological solutions, as well as projects for creation, redevelopment or demolition of research object;
● compliance analysis of results of working activities and scientific research results outlined in scientific hypothesis.

If objective is achieved, then it corresponds to scientific research, and non-correspondence requires repetition of the scientific research cycle or providing changes in formulation of scientific and technical hypothesis. The cycle allows finding out how much proposed hypothesis corresponds to obtained result of scientific research.

Researcher performs all stages of scientific research individually, from creative idea to final registration. However, any scientific research is carried out using certain methods and techniques, according to certain rules. Implementation of scientific method presupposes realizing and fixation of research objective, means of research (methodology, approaches, methods, techniques), keeping research focus on reproducibility of the result.

Master's student should only rely on a responsible, logically based and analytical approach in studying scientific background of chosen problem of her/his research work that will allow her/him to outline topic and implementation plan of her/his Master's thesis, which he will be coping with when preparing her/himself for upcoming defence of her/his qualification work (Master's thesis).

Conclusion

In the cycle of scientific research of Master's thesis, it is advisable to take into account the following provisions below:

1. The process of thinking should be considered as a technology.
2. The product of the thinking process is a thought form, which should be documented if necessary.
3. Documents (products of documenting the thought form) can be created solely for recording thinking activity or for using in the relevant project activities.
4. The purpose of the project activity is the transformation of documented thought forms into organizational and technological guidelines for further professional activities, if any.
5. The result of professional activities is in tangible embodiment of facilities (objects and processes), models of which were created during thinking activities, documentation and design construction activities.

The use of these provisions allows making the most of the democratic approach to choosing direction of scientific research, topic and content of Master's graduation work, which will contribute to training of highly qualified professionals in various fields of the educational process in Russia.

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