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CONSTRUCTION AND TECHNIQUES OF WRITING A SCIENTIFIC PAPER IN NATURAL AND ENGINEERING SCIENCES

ABSTRACT: In science and scientific research there is a wide spectre of fields and subfields which are not always strictly confined. Different classifications of sciences are also known. Numerous books have been published regarding scientific research, types of scientific papers and manners in which their results are published. This literature is very detailed and precise within international academic circles, especially the literature that relates to publishing scientific books and doctoral theses. However, there are certain dilemmas and inconsistencies which can confuse a young scientist when writing an original research article. After a brief review of issues pertinent to scientific paper writing, methodology of scientific research and type of papers, this paper shows characteristics and construction of an original research article. It shows a technique of writing a paper in all scientific fields and subfields with special emphasis on natural and engineering sciences and in accordance with international and domestic standards. Wider practical guidelines can be found in the cited literature, so they can be additionally used, if needed.

KEYWORDS: Construction and technique of paper writing, methodology, natural and engineering sciences, scientific research, types of scientific papers

INTRODUCTION

Within international academic circles, there are numerous similar definitions of science and scientific research, some of which are provided in the text that follows.

Science represents a rational form of social awareness with the main objective to research and affirm the objective truth about the world as a whole or a part of it, as well as different instances within it and their legitimacies.

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Basic purpose of science is “to get to know the world so that it can be surmounted by human“ and it primarily represents a “systemized code of knowledge“ (Subotić, 2009). Today, scientific research in all branches of activities has been developing intensely and it represents a creative process which contributes immensely to the overall well-being of mankind (Folić, Kurtović-Folić, 2009). Scientist must be absolutely dedicated to his/her work that is to science: reading, researching, writing. Long time ago, it was said that success comprises 5% of talent and 95% of work (Filipović, 2004). This statement primarily relates to science, art and sport.

Systemised and tested knowledge which is acquired through thorough research and logical analysis is called science (Carić, O., Carić, M., 2011). Facts, scientific principles and regularities are acquired on the basis of performed research. Thus, scientific research commences with an unexplored or partially explored problem. Based on that, it leads to new findings, results and establishment of new inter-relations. No matter what field of science is in question, the results must be accurate, the experiments must be repeated in a sufficient number of times (natural sciences), apropos data must be gathered in a sufficient number (social sciences). There are 3 basic scientific-research methods which are most frequently used (Šamić, 1988): normative (renders result as a norm, standard, usually on the basis of statistics); experimental (experimental verification of natural regularities); historical (reaches conclusions using history – chronology; mainly present in historical sciences). Apart from the above mentioned, the following methods are also applied: case study, survey, interview, genetic method and comparative method.

In order to be displayed to the experts and critics, the results of scientific research are published in domestic and international scientific journals, at scientific meetings, in monographs, project reports, encyclopedias, patents, master thesis and doctoral (PhD) thesis.

This text will pay special attention to the construction of the original scientific paper.

TYPES OF SCIENTIFIC PAPERS

Basic characteristics of a scientific paper with regards to its categorisation are: original research paper, short communication, professional paper, review paper, conference proceedings, poster, plenary (introductory) lecture, scientific monograph, monograph of international importance, chapter in a monograph or thematic almanac, research project, encyclopedia, patent, technical solution, master thesis, magister thesis and doctoral thesis.

Text that follows provides examples of certain types of scientific papers published by the authors of this article, or other authors, some of which were published in Serbia and some abroad. Ranking and categorisation of scientific papers is done in accordance with ranking of journals and editors, both domestic and foreign depending on where the work was published.

Original research paper/article contains results of its own original scientific research. (e.g.: Nedučin, D., Carić, O., Kubet, V. (2009): Influences of gentrification on identity shift of an urban fragment: A case study, *Spatium*, 21, 66–75).

Short communication represents preliminary brief display of author's original scientific research results. (e.g.: Pieralice, M., Sergio, L., Di Venere, D., Venediktov, P. (2011): A brief note on thermoluminescence analysis of photo-system II and lipid peroxidation during the shelf life of ready-to-use rocket (*Diplotaxis tenuifolia* L.), *Eur Food Res Technol*, 232, 919–923).

Professional paper processes and displays already known data. It requires author's pragmatic side, but it does not imply research originality. (e.g.: Ignjatijević, S. (2011): The influence of Gross Domestic Product and income on private consumption, *Economy – Theory and Practice*, 4, 105–110.)

Unlike original research paper, **review paper/article** does not contain new research results. In it, the author provides the overview of the latest research done by himself/herself as well as by other authors worldwide on a chosen topic, analyses them, compares and possibly suggests new research courses. (e.g.: Kubet, V., Carić, O., Ristić, D. (2010): *Werkbund Exhibitions – Reading Modernism Today*, *Architecture and Town Planning*, 28, 21–28)

Conference proceedings, unless they represent a review article, contain new, unpublished results. However, since reports are not reviewed always in entirety, they are not classified in scientific papers of the same level as papers published in scientific journals where review is mandatory. The same is true for posters, as well as for publishing the entire paper or abstract in conference proceedings or abstracts of papers at scientific conferences. (e.g.: Carić, O., Nedučin, D., Kubet, V. (2009): Cultural Street as a Result of Gentrification. Conference proceedings, The Eleventh National and the Fifth International Science Convention Planning, Projecting, Building and Renewal of Civil engineering, iNDIS 2009, Novi Sad, Faculty of Technical Sciences, pp.119–126)

Plenary (introductory) lecture represents an invited lecture. Even though they are reviews, these lectures contain results of authors original research as well, so they are usually published, and classified as original scientific papers. (e.g.: Caric, M., Milanovic, S. 1994: Advances in Kashkaval Cheese Technology. Proceedings of the Third California Cheese Symposium, University of California, Davis, San Francisco, February 14–15, 1994, pp. 1–17).

Scientific monograph represents a publication which independently and comprehensively elaborates on a given subject from a domain of some scientific area via methodological procedure appropriate to the topic and accepted in that science. A scientific monograph has to make a valid scientific contribution (e.g.: Carić, M., Milanović, S., 1997: *Processed Cheese*. Science, Belgrade, pp. 197).

Scientific monograph of international importance is dedicated to a theme which is wider than the one of national importance and is published in one of world languages. **Distinguished scientific monograph of international importance** must deal with a theme which is of utmost scientific interest and represents the top in its area. Publisher of this type of monograph has to be a recognized international publishing house with a long tradition in

publishing scientific literature (Ministry of Education and Science) (e.g.: Carić, M. (1994): Concentrated and Dried Dairy Products, VCH Publishers – Wiley, New York, p. 249).

Chapter in a monograph or thematic almanac is categorised in accordance with categorisation of the publication itself. (e.g.: Carić, M., Akkerman, C., Milanović, S., Kentish, E.S., Tamime, Y.A. (2009): Technology of Evaporators, Membrane Processing and Dryers. Chapter 3. in: Dairy Powders and Concentrated Products, ed. Wiley-Blackwell, pp. 99–148).

Apart from the aforementioned forms of publishing scientific results, there are also the following forms of displaying the results of scientific research: **research project, encyclopedia, patent, technical solution.**

Special types of scientific research which has a specific text organisation, form and construction are: **masters thesis, magister thesis and doctoral (PhD) thesis.**

CHARACTERISTICS AND CONSTRUCTION OF AN ORIGINAL SCIENTIFIC PAPER

General characteristics necessary for a high quality scientific paper, both in the field of natural and engineering (technical-technological) sciences as well as in medicinal and social sciences and humanities, are:

- Originality, which is basic and the most important characteristic of every scientific paper and contains the results of authorial research, thoughts and interpretations.
- Concise and clear defining and presentation, avoiding the elaboration of facts that are not directly connected with the research topic. Differentiating between important and unimportant and deleting the latter from the paper. Avoiding repetition. Avoiding explanation of things that are implied.
- The language of a scientific paper is specific. Its style needs to be clear and very concise and all the statements need to be documented by facts. Third person and passive are most commonly used verb forms in scientific texts.
- A good quality scientific work needs to comprise a coherent whole and the entire text needs to be in function of the basic idea that is the research theme. The aforementioned means that there is a logical connection among all parts of the paper.
- All the facts in the paper need to be adequately emphasized according to their importance.
- Every conclusion or thought present in the paper need to be explained and supported by evidence. The author must not fall under the influence of unconfirmed, apparent facts.

In his book *The Origin of Scientific Paper* M. Šamić (Sarajevo 1988) describes in greater detail the basic characteristics of a high quality paper, regardless of the field of science elaborated within it.

There is a general model used for construction of an original scientific paper, elaborated in detail later in this paper, which can be different in some details from journal to journal depending on the instructions given to the authors by certain scientific journals.

The value of a scientific paper depends on the category of the journal in the year in which the paper is published.

According to our current Law on Science (Sl. glasnik Republike Srbije, 2005, 2006, 2010, p.1) evaluation of national journals is performed annually for particular scientific fields by the corresponding Central Scientific Committee. The proposed list is afterwards accepted by Ministry of Education and Science and verified by the National Council. Journals are categorised as follows M51, M52 or M53. International magazines are ranked according to the ISI publications, Journal Citation Reports, SCI, SSCI (ISI list), and classified in the following categories M21, M22 or M23. In the process of journals evaluation, other ISI lists accepted by Ministry of Education and Science for every field and verified by the National Council can be applied as well. In technical sciences, the corresponding Central Scientific Committee can suggest one journal outside the ISI list to the category of internationally recognised journals – M24 for every scientific discipline it is in charge of. In social sciences and humanities, the corresponding Central Scientific Committee can suggest two journals outside the ISI list to the category of internationally recognized journals – M24 for every scientific discipline that is within its competence. Suggestions made by the all Central Scientific Committees are accepted by the Ministry of Education and Science, and the final ranking is verified by the National Council annually.

Despite measurable, exact standards, such as number of scientific publications, citation rate, impact factor and h-index, an objective evaluation of the success of the scientific productivity and quality at social and international level is a very controversial issue; an interesting discussion on those topics is presented in the paper by Kastori et al. (2011).

Construction of an original research paper contains the following elements:

- Title;
- Author(s);
- Résumé (Abstract);
- Keywords;
- Introduction;
- Material and methods (Research description);
- Results and discussion
- Conclusions;
- Acknowledgements;
- References.

Title. The title of a paper needs to be concise with as less words as possible (of 12 words maximum acceptable), but also precise and clear in order to

best represent the essence of the research and the article content. The aforementioned characteristics of the title of a scientific paper are also significant because of the Internet classification in international databases. Since they are mostly title based, a classification into adequate fields and subfields is performed, which enables high-quality search by professionals.

Author(s). In scientific paper writing, should be a team of multiple authors usually participates. A name of the author who gave the highest contribution to the paper realization should be listed as the first author. As a rule, the remaining authors are listed in descending order with respects to their contribution to all activities, from the idea, study and literature analysis, to planning and conducting the research and, finally paper writing. It is absolutely unethical to include the name of the author who did not participate in the activities of the paper realisation.

Résumé (Abstract). Résumé or Abstract is a short content of the scientific paper. Résumé sets the problem, the paper objective, lists the research methods and emphasises the most important results and conclusions reached. Scientific paper résumé usually contains 200 words maximum and is mainly limited by instructions given to the authors. It is written in the same language in which the paper is written, but also in English and sometimes in one more international language. Résumé represents a brief paper outline, thus it is advisable to write it once the paper is finished.

Keywords. Keywords are listed after the Résumé. They consist of several words – notions which need to be chosen so as to suit the content and the topic of scientific paper and they also need to be present in the text frequently. Keywords point to the essence of the scientific paper and facilitate easier Internet searches of scientific literature.

Introduction. In the introduction of a scientific paper, it is necessary to give an overview and explanation of the paper's theme, and to specify clearly and concisely the subject and object of the research. Reading the introduction, it is clear to the reader why that particular issue was chosen as the subject of scientific research.

Introduction also needs to comprise known and previously established facts, which are the outcomes of authors own research, as well as the results of other authors in the country and internationally, pertinent to the research topic. If the text, which relates to earlier researches of various authors is complex and comprehensive, contains numerous researches, discussions, confrontation of opinions and attitudes, it can be extracted from the introduction and placed under a separate title called „ Literature Overview“.

Material and Methods (Research Description). In this part of the paper which describes the used material and work methods, applied processes and means during the course of the research are shown. By doing that, the possibility of result comparison with other similar researches is ensured as well as their repetition. If the research methods are widely known, they should not be described in detail, but their names and literature sources where they are described should be listed. New methods, but also the modifications introduced into the standard methods should be particularly carefully described. If

experimental research is in question, the number of experiment repetition needs to be provided. Both in natural and social sciences, a statistical data processing is used wherever possible. Software used for data processing should be cited in the paper.

Research Results and Discussion. Research results are the research essence and the most important part of a scientific paper. Results need to be representative and well organised. Along with the results, it is necessary to submit logical explanation of the results. The data, which can be displayed in graphs or tables, are not repeated in the text. Figures, graphs and tables are only commented, comparisons and explanations given. In recent papers, useful conclusions are reached by 3D graph application. As a rule, the results which are obvious are not explained, but the differences pertinent to the results obtained in similar researches by other authors, national and international, are discussed.

Conclusions. Based on the discussion of the obtained results and comparison with the results obtained by other authors, new conclusions, findings and hypothesis are reached. There are general rules for forming conclusions in scientific paper. It seems that the most expedient and detailed instructions for conclusion formulation are given by Šomodić et al. (2004) in their book *Introduction into the Scientific Method*.

The following basic characteristics are considered as necessary parts of good conclusions:

Conclusions need to be brief, well formulated and clearly explained;

Conclusions need to be based on the data obtained in performed scientific research;

Counterarguments and the possibilities for alternative explanations and exceptions need to be commented on in conclusions;

The results need to be explained without their repetition and provided with comparison of other authors' earlier results;

Within conclusions, one needs to emphasise the scientific contribution of the performed researches and to describe their possible application – practical application of research results.

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Next to every acknowledgment, its reason must be specified.

References (Literature). Cited literature pertinent to the subject of scientific research the author deals with, enables the reader to get acquainted with the state of knowledge in the given research field in the country and the

world. Every citation needs to be brief, clear and directly assigned from the author. Only text from published publications of all types can be cited. As a rule, unpublished results are not used. The rules regarding citing the literature in the text vary depending on the references of certain journal editors. In international scientific journals and the world's recognized publishing houses, the most used ways of citing are Harvard Reference System and the Latin style, which have proved to be the most practical ones. Harvard Reference System enables simple perception of citation origin, since in the text, right after the citation, the author's name and the year of the publication are listed inside the brackets. The Latin Citation Style is less encumbering for the text, since the references are listed in footnotes and it is more precise because the page from which the citation is taken, even though paraphrased, is specified.

The remaining bibliographic data related to the paper, including the co-authors' last names and the initial letters of all the authors' names, are found in the reference list at the end of the paper, where all papers have been listed alphabetically starting from the last name of the primary author or differently if it was demanded by the publisher of scientific paper. Alphabetical system avoids confusion regarding ordinal numbers which were earlier often used to mark the paper in the text and in reference list at the end of the paper. Namely, every subsequent text insertion and order change represented a problem and generated confusion with the numbers.

CONCLUSIONS

Even though there is a wide spectre of research fields and subfields in science, the construction and technique of writing an original scientific article, regardless of the field, is very similar. There is a particular degree of similarity in the field of natural and engineering sciences where original scientific article implies experimental research. There are also general rules and standards regarding the writing of scientific paper worldwide, which have constantly been improving and have been subjected to minor changes, most often for the purpose of simplifying the writing process. Moreover, once a young scientist accepts and learns the scientific paper template, he/she uses it at all times for all the researches conducted and published it in our country and in the well-known journals worldwide, recognising the importance of continual development of this process.

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КОНСТРУКЦИЈА И ТЕХНИКА ПИСАЊА НАУЧНОГ РАДА У ПРИРОДНИМ И ИНЖЕЊЕРСКИМ НАУКАМА

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РЕЗИМЕ: У науци и научноистраживачком раду постоји широк спектар области и подобласти које нису увек строго разграничене. Постоје и различите класификације наука. Публиковане су бројне књиге о научноистраживачком раду, о врстама научног рада и начинима публикавања резултата научног рада. У међународним научним круговима ова литература врло је детаљна и прецизна нарочито литература која се тиче публикавања научних књига и докторских дисертација. Међутим, још увек су присутне извесне недоумице и неусаглашености које младог научника могу да доведу у забуну при писању оригиналног научног рада. У овом раду су, након кратког прегледа проблематике научног рада, методологије научних истраживања и врсти научног рада, приказане карактеристике и конструкција оригиналног научног рада. Приказана је техника писања научног рада за све области и подобласти наука, са посебним акцентом на природне и инжењерске науке, а у складу са светским и домаћим стандардима. Шира практична упутства налазе се у цитираној литератури, те се по потреби могу додатно користити.

КЉУЧНЕ РЕЧИ: методологија, научноистраживачки рад, врсте научног рада, конструкција и техника писања научног рада, природне науке, инжењерске науке