ISSN 1392–3730
JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT
http:/www.vtu.lt/english/editions

2003, Vol IX, No 4, 253–259

SYSTEMS APPROACH IN CONSTRUCTION – SCIENTIFIC SCHOOL OF A. A. GUSAKOV (SOCIAL–COMMUNICATIVE SURVEY)

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Received 27 Jun 2003; accepted 29 Okt 2003

Abstract. The scientific school of Academician A. A. Gusakov "Systems engineering in construction" has been approached by a social-communicative model. Scientists belonging to the above school have been identified and the period of the school formation has been determined. The research work carried out by A. A. Gusakov and his followers and their contribution to science and education have been discussed. The investigation is based on three methods: the analysis of the flow of theses, as well as the co-authorship and citation analysis.

Keywords: scientific school, construction, systems approach to construction, social-communicative model, analysis of the flow of theses, citation, co-authorship.

1. Introduction

The scientific trends developed by famous researchers during their lives, often referred to as scientific schools, play an important role in enriching our experience and knowledge in many fields as well as contributing to considerable advances in research and development.

For a long time, a research into the particular scientific school has been limited by the description of the biography of its founder and the main works of his followers. However, the relations between scientists were not taken into account. The investigation of the scientific schools from the communicative perspective was first undertaken by Prof O. Voverienė and her colleagues. She undertook a bibliographic (statistical) research based on the study of bibliometric characteristics of scientific papers (books, articles, theses, etc). In the present work, a social-communicative model [66] is used. It was applied to describe the scientific school of a well-known researcher Alexander A. Gusakov working in the field of computer-aided design and the use of systems engineering in construction.

2. Methods of research

The methods used in research are based on the communicative links between the members of the above school [65].

A social-communicative model relies on three methods:

1. The analysis of the flow of dissertations (theses);
2. The analysis of citing the founder's ideas (references) in the works of his disciples;
3. The analysis of the works written by the school founder with co-authors (his disciples) [66].

A social-communicative model provides for two kinds of relations: "teacher-disciple" and collegial (marginal) relations.

The relations of the kind "teacher-disciple" embrace the ideas and major research principles of the founder and their adoption and development by his disciples. These relations are identified by analysing the theses and references to the works of the leader.

The collegial relations show the similarity of the main principles and approaches to research in the works of the founder and his followers. These principles are identified by the analysis of works written with co-authors and references [65]. A research team may be considered a scientific school if it satisfies the following requirements [65]:

1. The core of the team is made of closely cooperating highly qualified researchers: eg of three or more Doctors of sciences (Doctors Habil in Lithuania, ie Candidate of science who got the Doctor's degree after 1992). They are supposed to defend their theses under the supervision of the founder of the school. Some other marginal researchers who maintained their theses under the supervision of other scientists but cited the works of the considered school's founder or were his co-authors may be referred to this school.

2. Three cases make the minimum sufficient number of citing and co-authorship.

According to a social-communicative model, a scientific school is an informal association of researchers under the leadership of a well-known founder of the particular scientific trend. They share the ideas and apply the methods and principles of research developed by the school leader [66].

Major characteristics of the scientific school are: a relevant research problem which may give rise to a particular trend of research; research and organisational skills of the leader helping to establish good communicative links between various team members contributing to the achievement of outstanding scientific results [65, 66]. The above social-communicative model was successfully used in describing the scientific schools of physicists [61], chemists [47] and the Academician A. Žukauskas' [51] school of power engineering in Lithuania.

3. Results and discussion

The present study results can hardly be exhaustive, because we think that a comprehensive investigation of Prof A. A. Gusakov's work may be conducted in his native country – Russia where a complete list of his papers and references to them in the works of other researchers may be found. However, the materials available allow us to identify and generally outline the scientific school of Prof A. A. Gusakov known as "Systems engineering in construction".

The analysis of the school is based on the material of the theses written under A. A. Gusakov's supervision, and other publications as well as on the references to his works found in the papers of his colleagues and followers in the period of 1961–2002.

It has been found that A. A. Gusakov was supervising the work of more than 50 post-graduates. His first disciples who defended the theses for the Candidate degree were V. I. Guzhov (1973), L.I. Kolybina (1974) and A. N. Tyutrin (1974); while those who submitted the theses for the Doctor's degree were V. O. Chulkov (1989), N. I. Ilyin (1989) and J. A. Kulikov (1989). Over the investigated period, 19 A. Gusakov's disciples defended theses for the Doctor's degree. Many of them further developed the problems first handled under the supervision of A. A. Gusakov. This is proved by their publications and references to the teacher's works. The diagram involving only a part of A. Gusakov's works or books edited under his supervision [27–28] is drawn which presents the scientific school of Prof A. A. Gusakov. It follows that the school numbers 160 disciples, including 30 Doctors and 130 Candidates of science who worked under the supervision of A. A. Gusakov or his followers.

These researchers may be considered the core members of the above school.

The school structure may be extended by more than 100 marginal members, including the scientists who published joint papers with A. Gusakov or cited his works, not being, however, connected by the link "teacher-pupil" to him. This shows that the A. A. Gusakov's ideas were widely accepted by various scientists. The problems which he investigated were further studied by the disciples of his disciples and other researchers working under the supervision of different scientists, continuing, however, the studies along the same lines and basing themselves on the same principles and approaches.

There are not a few scientists who experience the influence of A. A. Gusakov's ideas, not directly belonging to his school.

For example, let us consider our case. Our studies were largely influenced and inspired by the works of A. A. Gusakov [15–74]. In 1987, Prof A. A. Gusakov approved E. K. Zavadskas' monograph and wrote an introduction to it [15]. Later the author of the monograph consulted with A. A. Gusakov when preparing the next book [69] for publishing and the thesis for the Doctor's Sc. degree [68]. Then, Prof E. K. Zavadskas with the co-authors A. Kaklauskas (his disciple) and a German researcher Prof F. Peldschus published a monograph in English [74] comparing major concepts of the monographs published earlier in Russian [15–69].

This made the investigations of the authors of the present paper more easily available for foreign readers. Two Australian scientists, Engineer Prof M. Skitmore, and an operational research specialist E. Kozan made a review of this monograph which had been published in a British journal [58]. There they wrote: "Originating from Lithuania, this is the first book that attempts to encompass the use of multicriteria techniques in construction in both East and West...One of the major strengths of the book is in the examples given of the use of multicriteria decision–making techniques in construction, mainly in project selection, which appear to have been used successfully by the authors for several years, and many of which are unknown in the West".

Then, the authors continued [58]: "In many respects this is an outstanding book. The 16 page preface alone is a model of clarity and coherence and with a depth of conceptual understanding seldom found in the construction literature.

The question has to be asked "Has the former Eastern European countries anything of value to offer in this field? Are they ahead of the West? In the evidence of this book the answer is clearly a big *yes*".

Some years later the authors of the present paper published the monographs in English [72], German [67] and Lithuanian [71–73] based on the ideas of A. A. Gusakov's scientific school. In 1999, A. Kaklauskas was awarded the degree of Doctor Habil for his thesis [40]. In general, 18 disciples of E. K. Zavadskas and 4 pupils of A. Kaklauskas got the Candidate (after 1992 the Doctor's) degrees. In all the above monographs and papers, the works of A. A. Gusakov are cited.

Not a few articles, books and textbooks are in Lithuanian, because this is the state language used in

Lithuanian higher schools. This makes difficulties for making the research results easily available to foreign readers. The authors of the present study consider that the translation of the most relevant publications into other languages would be helpful for all the interested parties. The cooperation in compiling text-books and monographs may also be fruitful. In this respect, the experience of Prof A. A. Gusakov supervising joint projects associated with publishing monographs together with the Slovak [23–36], French [19] and American [22] scientists or making the translations of most relevant foreign publications is rather instructive. The authors of the present paper followed suit having published two monographs [73, 74] in cooperation with German authors and one together with Polish researchers [72]. One may judge from the titles of the works that they are made along the lines of the scientific developments of A. A. Gusakov.

It is hardly possible to mention all the publications of A. A. Gusakov's followers and their disciples here. It should only be emphasised that his disciples may be found in many scientific institutions of Russia [4–50].

Therefore, it may be assumed that a survey of major publications of the representatives of the A. Gusakov's school may be of considerable interest to foreign readers. The article [58] of the Australian scientists mentioned above, where only one of the publications based on the Gusakov's ideas is reviewed, encouraged the authors to write the present paper in an attempt to fill the informational gap about the research carried out in the former USSR and in the present Russia.

In studying the achievements of the Gusakov's school "Systems engineering in construction", the period of its formation was determined. A major assumption [51, 66] that at least three Doctors of science may make the school was used. The period of school formation is determined from the time when the first thesis for Candidate degree (PhD) was defended (not taking into account the thesis of the school founder) until the moment when the third Doctor's dissertation appeared (including the school founder's thesis).

The representatives of the scientific school of Prof A. A. Gusakov (Table 1) who were the first to defend theses for the Candidate degree included V. I. Ilyin (in 1978) and V. O. Chulkov (in 1978). The latter was also the first to submit the Doctor's dissertation. The disciples of A. A. Gusakov, N. I. Ilyin and Y. A. Kulikov, also defended the Doctor's theses later that year. Thus it may be stated that by the year 1989 the scientific school of Prof A. A. Gusakov was formed, which included four Doctors of Science, ie A. A. Gusakov, V. O. Chulkov, N. I. Ilyin and Y. I. Kulikov, as well as their disciples – Candidates of science and a considerable number of marginal members. The formation of the school took 16 years.

4. Review of research carried out by scientists of A. A. Gusakov's school

In 1970–2000, Prof A. A. Gusakov acted as opponent to more than 60 Candidate dissertations where the ideas of his scientific school were developed to a lower or higher extent. Therefore their authors may be referred to the above school as its marginal members.

The Doctors of science – the direct disciples of Gusakov's school prepared more than 30 Doctors and more than 120 Candidates of science and published more than 120 monographs and 3600 scientific papers in 30 years. They also developed new scientific approaches (ie probability and functional – system approaches) and defined new fields (ie organizational-technological reliability and adaptability to streamline manufacture in construction) to solve the problems of introducing IT (information technology) into construction and other industries (the data are taken from the publications about the authors of the book "Systems engineering in construction" edited by A. A. Gusakov, 2002, and the lists of their works).

In the early 70s, the Research institute of organisation and management of construction headed by Prof I. V. Komzin and Prof A. K. Schreiber (as a scientific adviser) was established at Moscow Civil Engineering Institute. At that time A. A. Gusakov, together with Y. A. Kulikov and N. I. Ilyin, offered to approach construction as a probabilistic system, also providing simulation models and design methods of organizational-technological reliability (OTR) of construction [16, 30, 34].

The methods of evaluation and the first design models of technological solutions [13, 34], as well as basic organisational principles of construction using automated control systems (ACS) were developed [18, 26, 30].

Statement and development of new research problems in the area of systems engineering in construction included project OTR, using computer-aided design systems (CAD) [34], integration of ACS and CAD, organisation design and design of construction and design organizations, etc. The problem of aerospace information technology in construction [35] was first stated. In collaboration with the laboratory of algorithms for brain of Moscow M. V. Lomonosov University, the use of neural network technology [33] in construction was tested. A new approach to study graphic representation and visual perception of information [18] giving rise to construction infographics as a new subject was also developed.

The above investigations made a basis for another new research subject – systems engineering in construction. In 1986, the department of computer-aided design in construction was founded in MISI, while in 1987, the preparation of Candidates and Doctors of science in the areas of "Automated control systems" and "Computer-

Table 1. Scientific school of A. A. Gusakov

Doctors of science (Dr. Sc. = Dr. Habil)	
1. Chulkov V. O., 1989	11. Jarovenko S. N., 1995
2. Ilyin N. I., 1989	12. Grigoryev Y. P., 1996
3. Kulikov Y. A., 1989	13. Shchegol A. Y., 1996
4. Borisova M. N., 1990	14. Denisov G. A., 1997
5. Vaganian T. A., 1991	15. Demidov N. N., 1998
6. Ganiyev K. B., 1991	16. Ginzburg A. V., 1999
7. Reznichenko V. S., 1992	17. Pavliuchuk Y. N., 1999
8. Sinenko S. A., 1992	18. Semitov R. A., 2001
9. Brechman A. M., 1992	19. Semechkin A. Y., 2002
10 Solunskii A. I., 1994	20. Kulikova Y. N., 2002
Candidates of science (PhD)	
1. Guzhov V. I., 1973	25. Solovyev V. S., 1988
2. Kolybina L. I., 1974	26. Tzai V. T., 1988
3. Tyutrin A. N., 1974	27. Pavlova Y. S., 1989
4. Kulikov Y. A., 1975	28. Shchegol A. Y., 1989
5. Ilyin N. I., 1977	29. Kotelnikov S. I., 1989
6. Chmelev A. A., 1977	30. Boicheva N., 1990
7. Ochrimenko A. V., 1978	31. Michlinovskii G. L., 1990
8. Chulkov V. O., 1978	32. Solunskii A. I., 1991
9. Sinenko S. A., 1979	33. Ginzburg A. V., 1991
10. Ganiyeva G. I., 1979	34. Shilovickii O. R., 1991
11. Borisova M. N., 1980	35. Suchachiov S. I., 1992
12. Puliko V. I., 1980	36. Saidiyev U. Ch., 1993
13. Piganov A. P., 1980	37. Kagan P. B., 1994
14. Vaganyan G. A., 1980	38. Ilyina O. N., 1995
15. Timofeyeva I. V., 1981	39. Denisov G. A., 1995
16. Maximov G. V., 1981	40. Kulikova Y. N., 1998
17. Demidov N. N., 1984	41. Gazinskaya Y. V., 1998
18. Yerokhin A. L., 1984	42. Petrakov A. I., 1999
19. Dragunavičius G. V., 1984	43. Rachina L. Y., 1999
20. Berndt Andreas, 1985	44. Kim A. N., 2000
21. Tuzova M. A., 1986	45. Kozlov V. I., 2000
22. Ugarov V. M., 1987	46. Shchetinina Y. N., 2000
23. Bagashvili V. O., 1987	47.Trofimov E. K., 2002
24. Sachkov V. S., 1988	
Marginal members of the school – Doctors of science	
1. Vasiliyev V. M., 1975	14. Alekseyev A. A., 1987
2. Krylov Y. P., 1977	15. Torkatyuk V. I., 1987
3. Suchachiov I. A., 1981	16. Zavadskas E. K., 1987
4. Azgaldov G. G., 1981	17. Vilman Y. A., 1990
5. Spektor M. D., 1982	18. Oleinik P. P., 1990
6. Evstifeyev V. N., 1992	19. Kostiuchenko V. V., 1993
7. Nesnov V. I., 1983	20. Kalugin Y. B., 1993
8. Naginskaya V. S., 1983	21. Kozhuchar V. M., 1993
9. Shakirov R. M., 1985	22. Kim I. V., 1996
10. Urazbayev T. V., 1986	23. Kharitionov V. A., 1997
11. Yegorov V. A., 1986	24. Bogomolov Y. M., 1998
12. Solovyev M. M., 1987	25. Kaklauskas A., 1999
13. Bulgakov S. N., 1987	26. Shepitko T. V., 2000

Marginal members of the school – Candidates of science more than 130 members

aided design systems" began. Now the founder of a new scientific school Prof A. A. Gusakov works at the department of CAD, being also the chairman of the Academic Council considering dissertations for Candidate's and Doctor's degrees.

The latter considered and approved 45 Doctor's and 96 Candidate's dissertations. All these works were made on the basis of major research developments of Prof A. A. Gusakov, regardless of the fact that he did not supervise them directly.

This publication is not complete because the list of researchers belonging to the scientific school of A. A. Gusakov does not contain all the names of scientists who defended their dissertations in other institutions or abroad. The authors hope that some of Prof A. A. Gusakov's disciples would undertake the task of making a complete and exhaustive survey of this famous research school.

5. Conclusions

The analysis of theses defended in 1970–2002 and publications in major scientific journals allowed us:

1. To identify the scientific school of Prof A. A. Gusakov "Systems engineering in construction" by applying the requirements of a social-communicative model of a scientific school.

2. To determine the members of the above scientific school. In the period of its activities from 1961 to 2001, the scientific school numbered 69 members, the disciples of Prof A. A. Gusakov, including 19 Doctors of science (Dr Habil) and 50 Candidates of science (PhD).

3. It has been found that marginals (the co-authors of some publications or researchers who cited the works of the school founder and his direct followers) may be included into the above scientific school. They were not linked with A. A. Gusakov by a relationship "teacher-disciple", but conducted research in the framework of major concepts of his school.

4. A major scientific centre of the school development has become Moscow Civil Engineering Institute (now, Moscow State University of Construction). Some research along the lines of A. A. Gusakov's school was conducted in other cities and towns of the former USSR and the present Russia.

5. It has been established that the scientific school of Prof A. A. Gusakov was formed during 11 years. This period begins with the time when the first student of A. A. Gusakov defended the Candidate's (PhD) dissertation and ends when the third dissertation for Doctor's degree (Dr Habil) was defended.

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