CLASSIFICATION OF RESEARCH AND DEVELOPMENT ORGANIZATIONS BY SECTOR FOR ASSESSMENT: CASE OF MATERIALS SCIENCE IN VIETNAM

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Abstract:

The research and development (R&D) system in Vietnam consists of diversified large number of institutions and it is impossible to evaluate the system as a whole at the same time in the current context. So assessment by subgroups of R&D institutions in the system may be a more feasible option. On the other hand, as the nature of assessment was to make comparison, so grouping by field of study may facilitate, at a certain level, the comparison. Furthermore, the results of assessment on a group of R&D in sector can help managers have clearer picture of R&D development of a field, for better service for S&T policymaking. To better understand about clustering method, this article analysed, as a case study, the R&D groups in the field of materials science. Materials Science is a field of interdisciplinary research which has received lot of attention of scientists community and research managers in recent years, it has become one of the most exciting research areas in Vietnam. By the method of data analysis and consultation with experts, the author of this article presents the concept, specialization of subjects under the study, and identify different types of R&D organizations R&D studying in Materials Science in Vietnam.

Keywords: *Methodology; Grouping; R&D organization; Assessment; Materials Science.*

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1. Introduction

In the context of current integration, the development of science and technology (S&T) for socio-economic development has become an urgent task. More than ever, S&T policy makers become more aggressive in finding out solutions to promote rapid S&T development to meet the requirement of socio-economic development. The Law on S&T in 2013 identified a number of new measures to be soon implemented, one of which was the assessment and restructuring of S&T organization networks. This was an important factor to stimulate S&T development based on competition philosophy. Law on S&T in 2013 had three articles (Articles 16, 17 and 18) concerning provisions on evaluation of S&T organizations, it showed the important role of this work.

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On 16th December, 2014 Minister of Science and Technology (MOST) issued the Circular No. 38/2014/TT-BKHCN provisions regarding guidelines on assessment of S&T institutions. However, in present Vietnam, the number of S&T institutions in general, and R&D organizations in particular, is quite large (684 R&D public organizations according to 2009 statistics of the Science Activities Journal, MOST [3]); while the assessment work is quite new with a limited evaluation capacity. It was therefore impossible for us to complete the assessment of the whole R&D system over a period of 3-5 years. This requires regrouping R&D organizations in reasonable way to assess with specific targets of assessment.

There were many ways to cluster R&D organizations (by management level, by function, by area of research, by geographical location,... [4]), however, one of the effective ways was the assessment of research organizations by area of study. The organizations grouped under a certain area of research might be of a moderate amount, not too big, feasible to achieve assessment purposes that was a very important point. To do this, the persons who classify the objects for assessment should understand clearly about the nature and actual situation of the field in question of Vietnam.

In the framework of this study, the authors described the method (including the criteria, and procedures of implementation) of clustering R&D organizations by area of study for assessment. Besides, the author also described in detail the groups R&D organizations in the field of Materials Science in Vietnam as an example to illustrate the methodology used for assessment, how it contributed to planning of S&T organizations and making S&T development policy.

2. Method of classification of R&D organizations for assessment

Clustering method was understood here as the criteria, methods and implementation procedures to classify R&D organizations by field of study. The process of clustering R&D organizations by studying documents, data and consultation with S&T experts by gradual narrow down of criteria through our steps of implementation.

The criteria of classification of R&D organizations was quite flexible, the main target was to group R&D organizations in the same field of study regardless of level of research (basic and deep). To choose what criteria it depends on specific requirements and ultimate purpose of the clustering organizations (to evaluate, to analyze the planning, to invest, or other purposes). Simply speaking, criteria here were limited within the field of

study. For example, with criteria that cover R&D organizations in the field materials S&T may be we obtained a group with relatively large number of organizations, while with criteria to cover only the field of Materials Science we will have a group of R&D organizations with in much smaller number, because Materials Science is a miniature within materials S&T.

The process of clustering R&D institutions by subject areas of research is in fact the narrow down from higher to lower step in order to get a group of organizations to fit the criteria set out:

Step 1. Determine the content and scope of a field research

The system of research areas is complicated by nature, it is divided/split into several levels - specializations at different degrees of research. The determination of content and scope of a study field to identify which groups of research institutions are involved is not an easy task. To do so, it should often base on the specific purpose of grouping R&D organizations, from there try to limit the field of research (that are criteria of the group). One of the bases for determining group criteria is the continuous factor: main outputs of the research can serve for socio-economic system and should limit in one or a group of objects to finally obtain a group R&D organizations in selected areas with the number of appropriate goals and conditions of using that group of organizations (to further evaluate, analyze planning, make investment, or for other purposes).

It is very important to get initial guess of expert with deep, broad knowledge on the research areas and their want to choose the quantity (high or low) of the R&D organizations under group, this step has strong impact on the overall direction of the next steps in the process.

Step 2. Identify specialists in the field of that research

This is an important, meaningful step to further clarify the content and scope of the selected research areas. The identification of specializations in one research area can be conducted in many ways, for example: by analyzing the division of specialization, journals, major field of research of scientific publishers in the world; or/and in collaboration with analysis on beneficiaries of research results of that area.

Step 3. Determine the major types of research in that field in Vietnam

From specializations identified in step 2, it needs to find out, on preliminary basis, what R&D organizations in Vietnam had conducted study that specialization and which type of research they focused: fundamental research; basic-oriented applications research; applied research; or development / experimental development. In essence, this is a preliminary

step to review R&D organizations of this group and to guide the work to be done in the next step. For example, R&D organizations in the field of Materials Science in Vietnam mainly perform basic research and basic-oriented application research, the next step is to review investment data for that type of research.

Step 4. Identify the R&D organizations in our country to assume the functions, tasks of that research

The realization of this step could be done by using different analysis techniques. It may be conducted through analysis of some important information gathered from R&D seminars, conferences and investment in R&D fields of research of concern. The main result is the integration of the conclusions drawn from that analysis.

In all implementation steps of the above process, all the analyses should be based on the advice and under the control of consultants with vast experience in the field of research of concern.

To illustrate more specifically to the implementation steps in the process of grouping R&D institutions, the authors will describe in detail the process of understanding, determining group of R&D institutions in field of Materials Science in Vietnam.

3. Case study on identification of group of research and development institutions in the field of materials science in Vietnam

During the implementation process to determine group of R&D organizations in the field of Materials Science in Vietnam, the author worked together with some knowledgeable experts, in the field of Materials Science, who had much experience in research, management and evaluation of this research area.

Materials Science is basic part of an important research field, which is the materials S&T. The reason for saying that it is an important area of research because: In the Government Resolution No. 88/CP promulgated on 31st December 1996 regarding Program of materials S&T development in Vietnam up to 2010, it confirmed: “Materials S&T is a set of science sectors in the study of composition, structure and processes of materials to create new materials with necessary technical features and for production on industrial scale. Advanced technology in materials industry contributes an important part to economic growth, is the basis for new industries and new products development and it facilitates optimal exploitation of resources for expansion of production, improving people's quality of life and accelerate the process of industrialization and modernization of the

country". This is one of the justifications for the establishment of the key state-level S&T Program KC02, named: Applied research and technology development of new materials [5]. This is one of the ten key S&T programs of state-level which have been implementing since 1996.

3.1. How the materials science was defined?

Materials Science is a science that is influenced very much from the general direction for S&T. Previously, in the medieval period, which Europe called "dark era", it was divided the academic fields into science and theology [7]. At that time, science is somewhat just separated from theology and the church to become an independent field of study. A scientific rudimentary background included only mathematics, geometry, biology, medicine, physics, geology without any place for Materials Science. This science was only formed after World War II, on the basis of merging some specialized areas such as physics, chemistry and metallurgy. Not all kinds of modern physics involved in Materials Science, only some main fields of solid substances physics, optical physics and a fraction of theoretical physics. Other sectors such as radio physics, astrophysics, nuclear physics are actually split into separate areas or have deeper integration into the field of wireless technologies such as electronics, optical communication, nuclear engineering, cosmology... Similarly, the participation of specializations of Materials Science in chemistry was still limited, namely in inorganic chemistry, computational chemistry, physical chemistry, organic chemistry (part of carbon materials, conductive polymers)... Sectors such as petrochemical, polymer chemistry, chemical technology, on the other hand, were separated or integrated into other technology fields.

Linkages between different scientific disciplines in Materials Science can be found in the object of study of this area - ie, the material. However, it was necessary to specify what new material was, because only talking about new material was not enough. There were research areas of new materials but had never been considered of Materials Science area, for example cosmetics, drugs, proprietary medicines, petroleum products... These areas were large enough to become private sector, with funding mechanisms and research conducting independently and production mechanisms with coordinated activities in the field of Materials Science.

The introduction of a limit scope for the field of Materials Science was difficult, because their boundary was not clear. In all countries, there should be a specific distinction. This distinction created the face of S&T in each country, it was also part of culture of national science. So in Vietnam, how do we perceive Materials Science in the S&T system. The following analysis may clarify this.

Currently, many people still think of Materials Science as a specialization of physics. More specifically, it is often said that Materials Science is the expansion of solid substances physics, with a limited understanding. Of course, there is no mistake in the geographical or academic framework, where it has only divided into rational and irrational. Obviously, such understanding of Materials Science is not appropriate, limited in many aspects leading to complexity in coordinating S&T activities relating to Materials Science. In terms of irrationality, please refer to three main factors, as follows:

- *First,* the definition of Materials Science is an extension of solid substances physics. It was only appropriate in the era of technology between year 1945 and the decade 1970-1990, where the outbreak of semiconductor technology, IC-based solid substance became modern technology. This was no longer correct after the 2000s when the Materials Science expanded into the field of organic semiconductors (conductive polymers, organic LED or OLED, organic screens as appeared today, for example), carbon materials (nanowires, C60, carbon fiber...), meta-materials have cyclic structure, nanostructured materials (nano ceramic, nanoparticles, nanowires...). The subject of traditional sciences itself like solids physics or inorganic chemistry also changed a lot. There are plenty of subjects for study today attaching with condensed matter physics, such as molecular magnets, which have a starting point from *complex inorganic materials*, referred to as material bases metal. These metal complexes often include an organic base (like C_5H_5NCOO) associated with one or various atoms of metal (eg, zinc, copper...), to produce materials that are commonly used in many different particular medicinal (eg, cis-platinum cancer drug is a compound of these)... The expansion of the object of study pushed the Materials Science out of areas of traditional physics and forces it to become an interdisciplinary sector.
- *Second*, due to the mistake on implications of the boundaries of Materials Science, there was a lack of knowledge of a related discipline like chemistry or metallurgy (broader than metals science research) in Materials Science Research.

  In recent years, managers have to deal with concerns of strengthening human resources in the field of chemical and metallurgical on the basis of materials science, physics sector. In the meantime, organizational structure or professional activities (such as activities of the Association of Materials Science) has been calculated for physics sector (even Materials Science is considered as a branch of Physics as stipulated in

the legal documents regarding the title of Associate Professor and Professor in Vietnam).

- *Finally*, the unreasonable organization was an invisible barrier to the common development of the academic unit. Organizational structure of academic units under the old USSR was too outdated and no longer relevant. For example, Department of Physics of the University of Natural Sciences, National University of Hanoi was an advanced unit, leading in Vietnam for decades after the war. During the flourishing period, the unit included many subjects of study, two of them were: Radio Physics and Nuclear Physics. These were of large scale with organized methodology, very successful in research and training as well as in attracting investment for basic research at the unit. However, academic activities carried names and prestigious of the Department of Physics that belonged to the field of Materials Science, primarily within the Solids Physics subject, which lately split into two subjects as solid materials and low Temperature Laboratory. Some other subjects in the Faculty of Physics were also involved in Materials Science research. Social investment on Materials Science requires the industry to be as a separate sector, located on and covered up some basic fields of physics and chemistry. By 2000, the Center for Materials Science started with a convergence of Materials Science researchers of the Faculty, School and it was somewhat prove of the existence and strong development of this important research area (Materials Science) in Vietnam.

3.2. Subjects of materials science

Materials science is an interdisciplinary field covering many research subjects and has the broad scope to use and develop knowledge. First, in terms of definition by worldwide published scientific journal, materials science somehow is related directly to their business use.

Publisher Elsevier, a famous scientist, has presently a magazine called Materials Science and Engineering [8], which has reference index relatively high (5 years IF ~ 2.5), divided into 3 separate journals:

- *Journal of Materials Science and Technology A* focusing on material structure, including: the nature, microstructure and fabrication technology. Previously, this journal published research works on cement technology, building materials, polymeric materials, but now, these kinds of research have not been accepted, mainly because the technology of cement and polymer materials is a too wide field and was transferred to another magazine. The purpose of the journal A is to publish experimental and theoretical research on load bearing capacity of the

material under the affection of nature, structure, microstructure and manufacturing technology or working environment. Thus, the magazine considers research on solid materials is key, in which physical properties such as optical-mechanical-thermal-electric are the most interested;

- *Journal of Materials Science and Technology B* defining the best object in solid materials and accepting only published research on solid materials with special functions (Advanced Solid-State Functional Materials). Categories of interest include solid materials related to electronic materials, electrochemical, ion materials, magnetic materials, optical materials, thin film sensor materials, blocks, nano. These objects can be of alloyed, ceramic material, microcrystalline form, or frozen solid glassy, amorphous. They can be semiconductor, solid dielectrics, including dielectric frozen solid polymer or conductive polymer. This journal also accepts research on nano structured materials, low-dimensional form (the dimension is 0, 1 or 2, which include dot materials, wires or thin films);
- There is a group of objects beyond the scope determined by Journal B and sent to the Journal C for the materials used in biomedical applications (but not medicines and proprietary medicines), including: simulate materials in biomedical systems, materials for biomedical applications, automatic arranged materials , smart materials, materials used in pharmaceutical preparations, materials as drug carrier or directives,...

As a general trend, many journals in the fields of physics are more open and more separate from published works in the field of materials science. For example, the Applied Physics of publisher Springer, - this magazine was Applied Physics Journal, now split up into Applied Physics A*: Materials Science and Processing* while the Journal B intended for laser technology and optical issues. Even journal Physics B of Elsevier still keeps traditional point of views of publishing only research in physics of freezing system, it has exceptions to allow publish fundamental research on Materials Science. Other magazines like Journal of Physics (Institute of Physics - English), Physical Review B, Physical Review Newsletter (American Physical Society), Journal of Applied Physics, or Applied Physics Newsletter (American Institute of Physics) also accept, to different extent, the research findings of Materials Science. But there is distinction between oriented research, and applied basic-research. There are many magazines only accept papers in the field of basic research.

Through the above analysis, it would be said that Materials Science includes the following specializations:

- Research on materials for electronic components, sensors, ceramic materials (electric, magnetic, dielectric), alloys, thin film, composite materials, cubic materials; this research direction derived from solid state physics;
- Research on materials for optical components solid, jelly (nano); this research direction is rooted from the field of optical physics;
- Research direction of new materials-oriented applications in bio-medical, pharmacy, environment; this is the traditionally direction in some sectors such as inorganic chemistry, pharmacology...;
- Directions for theoretical research based on computational physics of complex systems, at different levels, are from quantum physics or Newton mechanics; including new directions such as computerized materials science, bioinformatics,... Today these areas are mainly in computational chemistry with single-molecular systems and computational physics with solid systems, or systems particles;
- Research directions on traditional materials of metal industry, metallurgy as super-solid, super plastic, surface plated materials, special metal materials such as CARBID metal, metal hydrid and nitrid they are also in this group.

Research on the materials used in cosmetics industry, civil construction, paint or bleach, cleanser kinds or products processed from oil in the fields of materials science are not considered neither research directions under the sectors such as petrochemicals, organic chemicals,...

3.3. Type of research in materials science

According to industry experts, the majority of current research in materials science can be considered as basic research or applications oriented basic research. The basic research in materials science can be:

- Computational Physics of complex systems based on quantum theory;
- New materials, materials simulation, atomic clusters, nanostructures materials;
- The study of new physical phenomena at micro, nano levels.

Applications oriented basic research are primarily focused on:

- Sensors: sensor material for design and manufacture of sensors, specific surveys, product packaging;
- Micro flora system (Micro fluidics): design, fabrication, surveys of micro flora for specific applications;

- Diode type, different transistor, including long transistor, or graphene based diode, or research on electromagnetic characteristics of metal-graphene communication layer and similar;
- Semiconductor materials, magnetic materials, magnetic thin films, assorted magnets, some studies on materials for high-temperature superconductivity components (manufacturing, basic quality survey);
- Optical materials, optical semiconductors, doped semiconductors such as ZnO, ZnS, ZnS:Mn...
- Materials and spare parts for lighting solid such as LED, or organic LED (OLED);
- The nano suspension systems, jelly, pressed nano granular solid form;
- Alloy composite material, ceramic, carbon, polymers, biological origin materials;...

Although the boundaries are not clear it may include applied research on the following subjects in materials science:

- Components and Sensors (magnetic, electric, optical); diode, transistor type;
- LED and OLED;
- The micro flora system, biomedine and biomedical materials;
- The mechanics of materials, metals, composites;...

3.4. Situation of materials research in Vietnam

In the opinion of some experts in industry sector that Materials science research in Vietnam until now is mainly focusing on basic research and application oriented basic research, concentrating mainly in some large research institutions. This is confirmed by the following evidence:

a) Specialized Workshop in Materials Science

In Vietnam today, there are national, international conferences, seminars on Materials Science held annually or for every 2 years as listed in Table 1.

Table 1. National, international conference, seminars on Materials science in Vietnam

No	Name of conference, seminar	Host Organizations	Proceedings / journal	ISI issue
1	International conference on materials science and nano materials IWOMN	Institute of Materials Science	Advances in Natural Science: Nanotechnology	No

2	National Conference in condensed matter physics and materials science	Institute of Materials Science	Advances in Natural Science: Nanotechnology	No
3	International conference on Foremost issues in Materials Science(FMS)	Vietnam National University, Hanoi	IEEE Trans. Magn. [9]	Yes
4	Int'l symposium on nano-materials, technology and application (NANOMATA)	University of Technology, Vietnam National University, Hanoi	Materials Transactions	Yes
5	National Conference on Optical Spectroscopy	Institute of Physics	Journal of Science and Technology, Vietnam Academy of Science and Technology	No
6	National Conference on Theoretical physics	Institute of Physics	Communications in Physics, Vietnam Academy of Science and Technology	No

Conferences and seminars organized as mentioned above with the participation of more than 200 scientists from more than 10 countries, and at least 30 reports presented.

These organizations presented more reports in the conferences/seminars included: Institute for Materials Science and Institute of Physics under the Vietnam Academy of S&T; University of Technology and University of Natural Sciences under the National University, Hanoi; Hanoi University of S&T; Polytechnic University of Ho Chi Minh City, University of Natural Sciences and a number of key laboratories belonging to the National University of Ho Chi Minh City.

b) Implementation of research funded by NAFOSTED

According to funding statistics of the National Foundation for S&T Development (NAFOSTED) [6], every year about 80 research projects been approved for informatics mathematics, out of which, around 50 related to materials science. By 2013, more than half of projects were applied by research institutions in Hanoi (15/28), one quarter (7/28) in Ho Chi Minh City, and the rest were by local provinces such as Vinh, Thanh Hoa, Vung Tau, Quang Ninh, Dong Thap, one for each province. Not all proposals belonged to Materials Science sector, but research on Materials Science make up the majority (50/76 subjects) in which, much is done at the Institute of Materials Science (Academy of S&T of Vietnam), in Hanoi (11/50 subjects). Two units of are Institute of Physics (establishments in Hanoi and Ho Chi Minh City) and Polytechnic University Hanoi with the subject belong to other areas.

Research on Materials Science funded by NAFOSTED recently has mainly concentrated on the following institutions:

- Advanced Institute of S&T and the International Training Institute for Materials Science (ITIMS) of the Hanoi University of S&T: number subjects performed on annual average of 10 subjects, ratio implemented project/ number of staff was approximately 1/5;
- Institute of Materials Science of the Vietnam Academy of S&T (including 5 Sub Institutes, two centers, one key national laboratory, total researchers involved: more than 100), the number of average implemented projects: 12; ratio implemented projects/staff was approximately 1/10;
- Vietnam National University, Hanoi: The annual approved number of projects was very modest, averaging 4 projects/80 staff/lecturers relating to Materials Science from the two institutions, namely, the University of Natural Sciences and the University of Technology; ratio of implemented projects/staff was approximately 1/20.

Other units conducting research with limited funding sponsored by the Foundation, included:

- National University Ho Chi Minh City (mainly implemented at two facilities of the Polytechnic University and University of Natural Sciences);
- Hanoi National University of Pedagogy (mainly the Department of Physics).

Some new institutions involved in Materials science in recent times included:

- Tan Tao University (Long An province);
- Duy Tan University (Da Nang province).

The number of research projects at the new institutions showed a good sign in attracting qualified human resources with PhD degree in Materials Science obtained from abroad recently. They contribute to spillover the research in the field of Materials Science. However, they were quite a new team, research capacity still limited, in particular, research equipment still of low capacity, so their research results were mainly "thanks to" previous efforts of other units traditionally studied Materials Science with better facilities such as University of Natural Sciences, Hanoi and Ho Chi Minh City University of S&T or the Institute of Materials Science.

From the above analysis and through the information provided on the webpage of the organizations concerned, we can identify: group of organizations have traditionally conducted research in Materials Science belonging to Institute of Materials Science (VAST); Hanoi University of S&T (MOET); University of Natural S&T University (Vietnam National University, Hanoi); University of Natural Sciences and Polytechnic University (National University of HCMC). The statistics of institutions performing R&D in the field of materials science are shown in Table 2 below:

Table 2. Larger organizations having traditional research on Materials Science in Vietnam

Agency of Management Level I	**Agency of Management Level II**	**No**	**R&D Organizations in materials science**
Vietnam Academy of Science and Technology - VAST	Institute of Materials Science	1.1	Sub-Institute of Rare Earth Materials
		1.2	Sub-Institute of Optics - Spectrum
		1.3	Sub-Institute of electronic materials and components
		1.4	Sub-Institute of Minerals, Environment and Polymeric materials
		1.5	Sub - Institute for Metallic Materials
Ministry of Education and Training - MOET	Hanoi University of S&T	2.1	International Training Institute for Materials Science
		2.2	Institute of Technological Physics
		2.3	Advanced Institute of S&T
Vietnam National University, Hanoi	University of Natural Sciences in Hanoi	3.1	Faculty of Physics - Centre for Materials Science
	University of Technology	3.2	Faculty of Technical Physics and Nanotechnology
National University of HCMC	University of Natural Sciences, HCMC	4.1	Faculty of Materials Science
	Polytechnic University HCM City	4.2	Faculty of Materials Technology
		4.3	Key Laboratory of polymeric materials and composites
		4.4	Key Laboratory of materials technology
	Key Laboratory of Nanotechnology	4.5	Key Laboratory of Nanotechnology

Thus, under the above subheading methods, the R&D organization in the field of Materials Science Vietnam consists of 3 small groups: Institutes and Sub-Institute group; Faculty group; and Key laboratory group. All of three groups are public research institutes and public universities.

4. Conclusion

Through an illustrative example, this article has launched a process to identify groups of R&D organizations of the same field in service for appropriate assessment. The process started from the determination of concept or limitation in identifying a field of research, a subject/ type of research to find out the actual situation and the final definition of a R&D group/ organization in a certain sector in Vietnam. During this process, the study method was mainly documentation analysis, and expert consultation. According to the analysis, we provided important information for S&T policy makers for references in their professional activities, such as S&T planning in general and R&D organizations management, in particular. This can also use as basis for those who work on S&T evaluation, especially in assessing the performance of R&D organizations (e.g, the group organization R&D institutions of Materials Science). Rating a group of R&D organizations of close specialization is an advantage in searching S&T experts for evaluation, both in the evaluation itself and in the comparison of performance organizations in groups as well as it is a convenient for giving recommendations (after the review) for a field of study./.

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