To the Statement of Tasks of Research of Migration Processes in Education and Science

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Abstract

The issue of migration of students, postgraduates and scholars abroad (as well as within the country) are considered. The problem of migration is an important component of the general problem of sustainable development of the education system and science. General consequences of such migration are discussed. For example, if all scientists and educated students and graduates will go abroad, then the education system will fall into collapse. The positive aspects relate to the exchange of scientific knowledge with developed countries. Zero migration is also not desirable because it leads to isolation. Therefore, there is an optimal migration rate. Such questions, as well as many others, can only be solved by mathematical modeling. Therefore, in this article review of some possible models and problems of research tasks. Some classes of models for students and researchers migration are compared. Differential equations, system dynamics, cellular automata, artificial life had been considered. New types of cellular automata had been proposed as the models for migration problems. Also applications of artificial life approach for considering some problems of science development are discussed.

Keywords

Migration of students, migration of scientists, review of models, mathematical modeling, cellular automata, system dynamics, global knowledge

1. Introduction

Knowledge and creation is one of the main factors [1] and literature there. This problem has many aspects. So indicative is the cycle of Schlesinger in American education with a period of 15 years [2]. According to his research, the US entrants periodically change their preferences in higher education (with curiosity to pragmatic business education in curiosity to study how the world built). Other problems relate to the issues of optimization of the learning process, finding new forms (for example, distance education during a coronary pandemic, as well as after, in the post-modern society). Also, questions are also adjacent to the behavior of individuals taking into account their mentality. Models for their study are described, for example, in [3].

But there are many important tasks, and fundamental. But among the various tasks here we distinguish one of the tasks that is of great importance, namely, the issue of migration of students, postgraduates and scholars abroad (as well as within the country). Note that the problem of migration is an important component of the general problem of sustainable development of the education system and science. For example, if all scientists and educated students and graduates will go abroad, then the education system will fall into collapse. But migration has positive aspects. They relate to the exchange of scientific knowledge with developed countries. Zero migration is also not desirable because it leads to isolation. Therefore, there is an optimal migration

ISIT 2021: II International Scientific and Practical Conference «Intellectual Systems and Information Technologies», September 13–19, 2021, Odesa, Ukraine

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rate. This question, as well as many others, can only be solved by mathematical modeling. In general, this is a very difficult problem in this area. Therefore, in this article we offer a review of some possible models and problems of tasks.

2. Possible models of scientific migration

2.1 The simplest model that is suitable for such processes is to (very simplified) consideration in terms of competitive processes. The first most famous model of this type is the Volterra model [4]. One variable of such a model corresponds to the number of students, and the second variable corresponds to the total volume of students involved. The more ready students, the more this variable will be. When students for some reason becomes little, then the magnitude of the second variable decreases. The disadvantages of this model are that it is spatially focused.

2.2 Models in the classroom of ordinary differential equations. One of the simpler options is to write a system ordinary differential equations - one for the total number of students, postgraduate students and scholars; Others for the total number of students, scientists, etc., which go abroad, as well as the quality of evaluation (or even equation) for parameters describing conditions abroad: the need for skilled migrants, financial conditions, other conditions (cultural affinity - The distance of cultures, physical distance, etc.) This is one of the ways to use models (that is, empirical).

2.3 More simplistic, but more adapted to practical tasks is the system dynamics approach, launched by J. Forrester [5]. According to the concept of systemic dynamics, it is necessary to distinguish elements, their interaction between them, reinforcing or inhibiting the connection between elements. For the field of educational migration, it is necessary to adapt system dynamics. In principle, this can be done, but it is necessary to conduct a large amount of previous work, including in detail by drawing the corresponding diagrams of system bonds.

2.4 Another class of models that suits migration modeling is a diffusion equation. Then migration is considered with the help of diffusion equations. The disadvantage of such a model is the severity of finding the diffusion coefficients and other parameters. In addition, it is very difficult to take into account the mental identities of potential migrants. In fact, important features of donors and recipients are important: financial, cultural, social, etc. Also important parameter is the attachment to the native country and relatives.

2.5 Multi-agent models (masses - multi-agent systems) [6]. The models of such class are considered by the team of artificial agents who take some decisions in some branch, knowing the state of the environment, exchange information and decide. In migration models, educational agents can be equivalent to the identities, and the environment in which they are placed described by external factors that meet the above aspects.

2.6 Approach of the theory of games in the problem of educating migration. Another aspect of educational and scientific migration is more detailed taking into account the competitive aspects of this phenomenon. For such issues, a methodology in the field of science called the theory of games is quite well suited. In the problem of educational migration, there are also aspects of competition. Note if knowledge and those who produce this knowledge are the main resource of sustainable development [1], in the future, the struggle for the distribution of these resources becomes fierce and will take new forms (sometimes cruel). Regarding migration tasks, then part of them can be adapted to the problems of the theory of games. The country - migrant donor is also considered as a separate agent. Competition between these agents takes place for the involvement of educated frames. In principle, the game should be unanimate, because in the normal course of things, the general goal would have to ensure the progress of the aggregate of countries. In this case, a separate unit is a definition, what is this progress and which quality and quantity should be knowledge to ensure this goal.

2.7 MASTER EQUATIONS. In this division, I would like to remind you of another class of models that in principle can come to migration tasks, namely Master Equations, or kinetic equations. In this approach, an element that has certain set of values and records the laws of evolution of these states that have physical justification [8, 9] are recorded. In principle, this approach can solve all migration tasks, but it is very difficult, and it is practically impossible to apply to important applications due to the impossibility of gathering the necessary data.

3. Modeling migration in the class of cellular automata

There is another class of models that have been well established for applied tasks, namely a model with splitting space on cellular elements and a record of equations to change the state of these elements. Such models are called cellular automatics models [10, 11]. Note that such statutes exist for other models [12].

3.1 Models of scientific migration on the basis of cellular machines. The idea to set up the method to migration is as follows. All available geographic space is divided into geometric elements, that is, in a simpler case, a uniform geometric grid is imposed. At the first stage, such a grid is superimposed to Ukraine. Fixed number of educated frames is one migration agent. Then the number of agents in the cell corresponds to the total number of educated frames.

Further in a simpler case model, all countries abroad can be considered as one general element. Then in the middle of Ukraine, the process of migration is considered as a sequence of steps from the cell into a cell in the middle of Ukraine with a final step behind the boundary in a conditional general element. The model can be easily refined if and a foreign cell to break into cells that meet separate foreign countries. Further, as in other applications of cellular machines to spatial evolution tasks in various fields of migration [11], the laws of changes in cell changes are recorded. These laws take into account all available information as external and mental. Note that such an approach showed acceptability in modeling the spatial distribution tasks (despite the local nature of the dynamic laws of classical cellular machines [10,11]. But you can generalize cellular machines under migration. The fact is that classical cellular machines were built on the base E - classic Euclidean Dimension Space 1D, 2D, ..., ND. The structure of the base space Es set the measure of the cells. This, in turn, set the local challenge cell and which determines the dynamic law of the cellular automaton. To the base space of classical machines in the applied Tasks are tied by various thematic layers: financial, economic, cultural, etc. These thematic layers can be replaced by E. E. Moreover that there is so formed statistics. But you can enter other measures of the cells that will be taken into account the formed Proximity of countries: historical, cultural, diplomatic.

4. The struggle for the allocation of resources in science and education

4.1 Modeling the dynamics of science as a system, with a large number of scientists, infrastructure, funding

The question of modeling the development of science that produces knowledge as a product of evolutionary development is of great theoretical importance. A large number of studies (both specialists in scientometrics and scientists from other fields: physics, mathematics, biology, economics, sociology, etc.) are devoted to these problems. But there is still a need to attract new concepts, ideas, models, including the real management of science. Therefore, here we present one approach to modeling such processes. In science, scientific schools, the following basic components: scientists (as a rule, the association of scientists to study a particular field or more often a scientific problem, finance allocated to the scientific field, but more often to a scientific problem, the branches of science as elements). project) of theoretical, experimental knowledge, governing bodies that distribute funding (for research and training), and educational institutions (usually at the university level) that transfer knowledge, prepare new generations of researchers and shape the preferences of graduates.

Analyzing such aspects of science research as systems and its modeling, one can come to unexpected analogies with models from completely different fields of research - namely with some aspects that are inherent in the so-called "Artificial Life" (AL, ALife, artificial life) directly [13, 14]. Typical tasks there are studies of the struggle of groups - antagonists (or collaborators) for resources. Some key components of the AL approach are:

1. Cell space
2. Spatial distribution of resources needed for life
3. Agents that can move through the cell space and which can be in the search for resources, the struggle for resources, destroy each other, have different preferences for behavior
4. There may be associations of teams of agents with tactics and strategies of behavior
5. The birth of young generations of agents in the team and the death of the old
6. Rules of conduct are "embedded" in individual agents
7. The possibility of a certain combination of rules of conduct of agents of "parents" at the birth of an

agent of a "child" of a new generation at a "meeting" of "parents" and "birth" of this agent of a new generation.
(As well as many others).

A review of the properties 1-7 above and the properties of scientific activity allows us to draw conclusions about some analogies that allow us to apply the concept of AL to the consideration of science as a system. Let's show it at first on the simplest example.

Example 1. The struggle of scientists for finance.

Let the branches of science be placed as a "scientific" space of ideas (by the way, there are now studies to build an "atlas of science", however, without cellular concepts). Let the individual scientist be presented as an agent who can move through the cellular space of "ideas" (space of science) and funding. Scientists are united in "scientific schools" (teams of agents). Note that usually there are not many schools, say 2-5. The state (or relevant institutions) provide funding for a particular field of science (distribute finance resources on different sets of resources). Then school teams look for resources (consciously or unconsciously), fight with each other, develop, survive, or die. Note that the distribution of finances by industry is the management of science (of course, under many other conditions - the rules of grants, selection criteria and much more). Even using such a model, you can try to get a model from the class AL to model and manage scenarios for the development of science). But this model is suitable for considering the competition of stable / established scientific schools.

It is clear that considering only financial issues is only one aspect of science. Thus, the intellectual attractiveness of the field of knowledge for the scientific school (as well as for the individual scientist) is also important. For example, some scientists do not want to work on the task of designing weapons of mass destruction for any money. Also important in scientific discovery is often the role of individual scientists (who are distant from colleagues, or are not in the "Core" of the scientific school). Therefore, it is important to introduce other (in addition to financial measurements) dimensions, "dimensionality" (say, attractiveness, metrics of "proximity" of different branches of science, etc.). Really important are the physical (geographical), political aspects of the development of science and science schools. Yes, many scientists will not want to go to work in science, which may be the most developed in the world, but in aggressor countries, or with dictatorial regimes. It is also important to take into account the processes of aging and generational change in science and scientific schools. Then, in principle, it is necessary to build a multidimensional cell space, where different coordinates will correspond to different aspects of science as a system, and the echo of agents will then take place in this multidimensional space.

Example 2. Taking into account the change of generations.

In addition to the details of Example 1, aspects of generational change and sustainable development of science can be added. Again, let's illustrate this with one of the simplest examples. Suppose that only universities train and graduate young scientists. It is then that universities set priorities in the choice of scientific field and scientific tasks, ethical principles, morals. It may also be that several teachers have the greatest influence at the university. Other issues can also be considered, including external regulation of learning processes, distribution, funding strategies for universities and specialties in them, etc. Then there are also clear analogies with the approaches of AL (transfer of knowledge and preferences) to the next generation.
In general, a set of such models can be important for the management of science and education.

4.2 Extending the approach of artificial life to some problems of social relations

Let us recall an approximate description of the soft approach in artificial life. There is a space in which representatives of competing groups that can move in search of resources are located. There is also some location of resources in the search space. As a rule, in AL the space consisting of association of cells is considered. In the classic examples that came from ecology, resources are edible resources and artificial life means fighting for them (the example of sugar is the best known).

It is suggested that the ideas of such a description can be transferred to some tasks of society. Such tasks can be difficult, so here we describe the idea with simpler examples.

Let us have the task of fighting some ideas for the minds of the population. Suppose there is idea A with many carriers of ideas (mass media, TV, Internet) and another (antagonistic) idea B. Imagine that the population is a resource for idea A or idea B. That is, ideas are analogs of teams in classical artificial life. Then the population is a resource, and consumption of a resource by ideas A or B is analogous to consumption of an edible

resource. Here it is necessary to take into account the perception of the population to the ideas of A or B, the forms of their presentation, the attractiveness of the forms of presentation of ideas to the population, etc. Ideologists and flight consultants of different ideas are looking for ways to bring ideas to the public: what ideas; how to deliver them; how to take into account and make ideas attractive to the population. Acceptance of the idea of A or B by the population is analogous to the classic AL: teams eat resources. Aspects of improving the attractiveness of ideas are analogous to management processes. Note that such a transfer of ideas is possible in the case of only one community (team, idea). Yes, migration from only one country can be considered. You can also adapt artificial life ideas to some cybersecurity issues. For example, the spread of fakes and the reaction of society to them. Then the analogy is that a fake "eats" part of the population depending on the characteristics of society.

It is also possible to consider the spread of epidemics as the spread of a virus - an analogue of the virus team, and the team, which increases in size with the spread of the epidemic. Note that further generalization of the models leads to the problems of artificial life in another (non-cellular) space, and, for example, to the problems of distribution in the network structure. You can also consider problems for the dissemination of ideas in a mental space other than the physical. A possible example is a change in scientific paradigms in a field of science.

5. Migration processes in education and science as an example of the struggle for resources

5.1 General problems of sustainable development in education and science

A separate but important task in the field of modeling is the migration processes of highly educated professionals: primarily scientists, students, graduate students and others. Scientific migration has two aspects - domestic and international aspects, ie migration abroad. Here we will point out one very important aspect of migration in education and science both for an individual country (especially, for example, for Ukraine) and for the world community as a whole (global aspect). The main problem is the sustainable development of the reproduction of necessary knowledge [1]. At the same time, there are many tasks in this issue. First, it is a problem of new knowledge. Secondly, it is the sustainable development of educational and scientific infrastructure. The problem of migration belongs to this range of problems.

5.2 General description of the migration problem

From the point of view of the approach of an artificial life it is possible to allocate such elements. In this problem, foreign sources provide resources, and the contingent of migrants is divided into communities from different countries, which implicitly compete for resources. Resources can be money, highly qualified positions and much more. It should also be noted that the same indicators should be taken into account for the internal situation in Ukraine. But we still need to take into account the "homeliness" of agents, the attractiveness of the country as a whole, the prediction of the future situation in the country and other countries. In this case, the problem can be considered locally in time, ie at short intervals with constant conditions. If it is desirable to study this in order to optimize the scientific infrastructure, it is necessary to predict changes in the world situation. At the same time there are interesting and new for the subject of artificial life issues of resource management over time. In many cases, this directly leads to a new issue of sustainable development of education and science.

Here we describe informally part of the problem. Let $\vec{R}_z$ - resources for migrants abroad at the measurement scale [0, 1], $\vec{R}_v$ - domestic resources in Ukraine. When, $\vec{R}_v \to 0$, $\vec{R}_z \to 1$everyone will emigrate from Ukraine, and when $\vec{R}_v \to 1$, $\vec{R}_z \to 0$, everyone will stay in Ukraine. Clearly, there should be an intermediate value $0 < \vec{R}^{\,z} < 1$ that should be optimal for the sustainable development of education and science in Ukraine. Another thing is that these productions are part of the problem of sustainable development. The main resource of the process of sustainable development is knowledge (Makarenko, 2020). With regard to Ukraine, this leads to the following issues (which still need to be addressed): what knowledge is needed now and in the future; their division into fundamental and applied; how this knowledge is generated depending on the infrastructure. And all this very much depends on the number of scientists and students $0 < N_v < 1$ who remain in Ukraine.

6. Discussion, conclusions and staging of new tasks

In the previous sections, a comparative review of some models of scientific migration was given. Based on such an analysis, it can be assumed that there are already promising approaches to modeling the described issues. Among the models considered, models of cellular machines are particularly promising. They are now developed by their computer sales and passes the process of searching and adapting data required for simulation.

However, the solution of applied migration tasks leads to the need for consideration a global problem - namely the problem of sustainable development, the problem of the emergence and dissemination of knowledge [1]. So far, it is not solved by the end of the task of prediction of achieving the required minimum level of knowledge. This requires special research. Then this global condition may be subordinated to the task of educational migration. First of all, it is necessary to determine the minimum gain of knowledge for humanity as a whole (that is, what minimum level of knowledge is required). Then it is necessary to determine the goal for each of the countries, as well as primarily for business and industry of each country. In this case, there is a clear conflict of interest - between the global goal and the purpose of business profits. In this case, business profits can increase due to educational migration, reducing the emergence of fundamental knowledge. This problem may require the use of the theory of non-antagonistic games. Note that similar problems arise in the distribution of a limited number of abstracts between various scientific disciplines (if necessary to provide a total knowledge).

Thus, summing up, we can say that in the proposed article outlines the ways of studying the important scientific problem of educational migration in various aspects.

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