Towards the development of a toolkit for assessing the critical competencies of agricultural sector employees

A A Aletdinova\textsuperscript{1,2}, A I Kiprisheva\textsuperscript{1}

\textsuperscript{1}Automated Control Systems department, Novosibirsk State Technical University, 136, Nemirovicha-Danchenko st., 136, Novosibirsk, 630073, Russia
\textsuperscript{3}aletdinova@corp.nstu.ru

Abstract. One of the tools for assessing the critical competencies of employees can be an expert system. The authors conducted a theoretical study of critical competencies and identified the following groups relevant in the agriculture: intellectual-educational, communicative, motivational-volitional, management, networking, environmental. Considering competences as variables of the expert system, it is necessary to determine the method for obtaining their values. Today there are no methods for assessing critical competencies. Therefore, the authors decided to use the results of the survey of respondents after the adaptation of existing methods for determining personality characteristics in psychology. Based on the correlation analysis of the results of the survey, the authors excluded the multicollinearity of competences and selected significant variables that were recommended for use in creating an expert system.

1. Introduction
The name of the economy at the present stage of development is the digital economy or the economy of competencies. The employees of the agricultural sector in the conditions of scientific and technological progress will need to acquire new competencies in areas that previously did not belong to the agro-industrial complex, new skills in the field of ecology and sustainable development, ICT (information and communication technologies), and other new agricultural technologies will be required. It is possible to estimate which competences will give a great economic return by developing an expert system. The main difficulty is related with the selection of variables.

2. Related work
The use of expert systems occurs in different areas. For example Italian researchers from the University of Milano-Bicocca, the Department of Earth and Environmental Sciences, Francesca Grisonia, Viviana Consomnia, Marco Vighia, Sara Villaa, Roberto Todeschini, deal with environmental issues [1]. A.O. Mazilov and R.I. Bazhenov showed the use of an expert system for diagnosing a personal computer malfunction [2].

The theoretical productivity of the implementation of the tasks of constructing expert systems in the field of psychodiagnostic studies to control the foundations of established systems of psychological cognition has been proven for a long time of research [3, 4, 5]. Interest in the field of the humanities gives rise to the principle of creating the ideas and methods of the expert systems themselves.
Expert systems are computer systems containing a knowledge base in a narrow domain, as well as means of access and operation of this knowledge. In order to make rational decisions by man, expert systems are preliminarily worked out by experts who are specialists in a certain field. The principle of working with the system is based on user polling and making the system’s opinion on the case on fixed indicators.

The state of automation of psychodiagnostics and professional counseling is determined by the presence of a fairly large number of individual programs that automate the stage of presenting tests and decipher the results by key. Such systems, as a rule, isolate at the output of numerical vector or template blanks of the interpretation of these vectors, which do not reflect the individual characteristics of the subjects. This situation is connected with the objective complexity of individual psychological mechanisms, the acquisition of which requires the participation of professional experts who are able and willing to share their experience and skills.

The knowledge base is an essential component of the expert system, the main purpose of which is to assist less experienced people in finding an existing description of how to solve any problem in the domain. Let us highlight the critical competencies that agricultural workers in the network economy have as variables of the expert system.

The formation of critical competences involved by A.H. Maslow (the theory of self-actualization, disclosure of creative abilities, Maslow's pyramid, 1954), G. W. Allport (free realization of human potential, 1939), C.R. Rogers (achievement of the “I am perfect” model, 1947), J. Rasmussen (individual productivity model, 1983) and etc.

In our opinion, the following groups of competences will be significant for workers of the agricultural sector: intellectual and educational; communicative; motivational and strong-willed; management; networking; environmental. Analysis of scientific publications and web resources shows that there is no database with data on the possession of critical competences by employees of the agricultural sector of Russia. In addition, there are no tools to assess these competencies.

3. Methods
Variables in expert systems are defined by a set of user’s tasks. In our case, this list is limited to estimating the human capital of agricultural sector workers.

The next requirement for the expert system variables is the technique of forming the expert system. Methods of psychology will provide expert self-assessments of respondents for each of the competencies. The limitation will be the inaccuracy in the respondents' self-assessments; often, the estimates given out can be better than the real situation, so they will be close to the “I am perfect” model (by C. Rogers). In addition, the expert system will have other limitations, determined by the degree of generality (concreteness) of knowledge on the organization of labor in the agricultural sector, accessible to the user.

An important requirement for variables is the necessary language of communication and the organization of the dialogue of the system with the end user.

Modern scientists and educators set the task of changing the model of training specialists in which the cognitive abilities of people must come first. Cognitiveness is the capacity for mental perception, processing of external information [6, 7, 8, 9]. In psychology, this concept reflects the beliefs, desires and intentions of the individual. In a broader sense, it is used to describe knowledge or self-knowledge. Cognitive processes include memory, attention, perception, action, decision making, and imagination. Scientists are trying to identify cognitive components and emotions. Features of the assessment of cognitive abilities of workers include:

- lack of a uniform technique;
- application of psychodiagnostic methods for their identification and evaluation;
- inaccuracies due to the subjectivity of the opinions of both respondents, experts and persons conducting research.

Most of the critical competencies are based on cognitive skills, so there is a difficulty in their assessment by statistical methods. It is necessary to resort to psychodiagnostic methods or expert evaluations.
Thus, the authors have identified methods of psychology that can be adapted to the objectives of the study (Table 1, 2, 3, 4).

**Table 1.** Modification of psychology techniques for the assessment of intellectual and educational competencies

| Method name | The authors | Features of modification or exclusion from the toolkit |
|-------------|-------------|------------------------------------------------------|
| Assessment of the ability to self-development and self-education | V.I. Andreyev [10] | Key ranges increased |
| Readiness for self-development | V.L. Pavlov [11] | Key ranges increased |
| Value questionnaire | Sh. Schwartz [12, 13] | In addition to changing the rating scale, a serious modification and reduction of questions is required. |
| Creativity | E.P. Torrens [14] | The technique is excluded, because based on the analysis of figures, has difficulty in processing the translation of the results into statistical data |
| Creativity | N. Vishnevskaya [11] | Key ranges increased |

**Table 2.** Modification of psychology techniques to assess communicative competences

| Method name | The authors | Modification Features |
|-------------|-------------|-----------------------|
| Tolerance Index | G. U. Soldatova, O. A. Kravtsova, O. E. Huhlaev, L. A. Shaygerova[15, 16] | Key ranges increased |
| Tolerance Measurement | V.S. Magun, M.S. Zhamkochyan, M.M. Magura [17] | Without changes |
| Communicative tolerance | V.V. Boyko [18] | Increase and change of borders is required. |
| Diagnosis of "interference" in the establishment of emotional contacts | V.V. Boyko [18] | Key ranges increased |

There were selected methods of Russian-speaking scientists or modified for Russian respondents. In a networking group, one competency needs to be defined – ownership of information and communication technologies. It is not cognitive, but it acquires importance in the conditions of digitalization of the economy. The authors developed a questionnaire on ICT ownership, because a method of psychology defining this competency was not found.

Ecological competences make it possible to form an ecological society. Unfortunately, psychological tests were not found for their assessment; therefore, the authors developed a questionnaire “Lean Production” “Promoting the Concept of Sustainable Development”. The modification of existing methods of psychology has been reduced to increasing or changing the boundaries of the range for a key, changing the formulation of conclusions, reducing some of the questions aimed at identifying other characteristics of people. This is due to the specifics of our research.
Table 3. Modification of psychology techniques to assess motivational and volitional competencies

| Method name                                      | The authors                  | Modification Features                                                                 |
|-------------------------------------------------|------------------------------|--------------------------------------------------------------------------------------|
| The need to achieve the goal                     | YU.M. Orlov [19]             | Requires increasing and changing the boundaries of the range, reformulated the conclusions |
| Hardiness                                        | S. Muddi [20]                | Without changes                                                                      |
| Degree of readiness (propensity) to risk         | A.M. Shubert [21]            | Requires increasing and changing the boundaries of the range, reformulated the conclusions |
| Motivation for success                           | T. Elers [21]                | Requires increasing and changing the boundaries of the range, reformulated the conclusions |

Table 4. Modification of psychology techniques for assessing management competencies

| Method name                                                                 | The authors                  | Modification Features                                                                 |
|---------------------------------------------------------------------------|------------------------------|--------------------------------------------------------------------------------------|
| The level of self-actualization of personality (CAT or SAMOAL questionnaire) | E. Shostr, adaptation L.Ya. Gozman, Yu.A. Aleshina, M.V. Zagikoy, M.V. Croz, N.F. Kalina [22] | Without changes                                                                    |
| Morphological test of life values (ILCC)                                  | I.G. Senin, adaptation V.F. Sopov, L.V. Karpushina [23] | Reduced the number of considered areas                                                |
| Diagnostics of the orientation of the person                              | Methodology of V. Smekal, M. Kucher, modified profile of B. Bass [24] | Reformulated conclusions                                                              |
| Emotional intelligence                                                    | N. Hall [25]                 | Conclusions and rating scale changed (divided into three intervals)                   |

After modifying the methods, it is necessary to test them on a sample group of respondents and to conduct a correlation analysis of the results obtained, i.e. calculation of cross-tabulation, margin frequencies and association coefficients, determination of conjugacy of competencies and identification of multicollinear competencies.

Crosstab allows combining the frequency of occurrence of observations at different levels of the considered signs. Marginal frequencies allow us estimating the distribution of frequencies in separate columns and rows of the contingency table of signs $X_i$ and $X_j$ (in our case, competencies). The calculation of the coefficients of the association allowed us identifying the relationship of signs and analyzing the presence of multicollinearity. It is possible to eliminate multicollinearity on the basis of, for example, the introduction of the resultant variable ($Y$) as self-evaluations of respondents to their critical competences and analysis of links with the results obtained using the methods of psychology.

4. Results
There were recruited 200 agricultural sector workers aged 18–68 years for a selective survey. After the initial selection of methods and supplementing them with developed questionnaires, 18 questionnaires were obtained. We have introduced the following notation (Table 5).
Table 5. Modification of psychology techniques for assessing management competencies

| Competence                  | Authors of methods                  | Designations |
|-----------------------------|-------------------------------------|--------------|
| Self-development, self-education | V.I. Andreev                          | X1           |
| Self development             | V.L. Pavlov                           | X2           |
| Creativity                   | N. Vishnevskaya                       | X3           |
| Tolerance                    | G.U. Soldatova, O.A. Kravtsova, O.E. Hukhlaeva, L.A. Shaygerov | X4           |
| Tolerance                    | V.S. Magun, M.S. Zhamkochyan, M.M. Magura | X5           |
| Communicative tolerance      | V.V. Boyko                            | X6           |
| Establishing emotional contacts | V.V. Boyko                           | X7           |
| The need to achieve the goal | YU.M. Orlov                           | X8           |
| Hardiness                    | S. Muddi                              | X9           |
| Risk preparedness            | A.M. Schubert                         | X10          |
| Motivation for success       | T. Elers                              | X11          |
| Self-actualization of personality | E. Shostr                           | X12          |
| Professional self-realization | I.G. Senin                           | X13          |
| Availability of management group competencies | V. Smekala, M. Kuchera           | X14          |
| Emotional intelligence       | N. Hall                               | X15          |
| Command of ICT               | developed by the authors              | X16          |
| Lean                         | developed by the authors              | X17          |
| Promotion of the SD Concept  | developed by the authors              | X18          |

Based on the calculation of the association coefficient, there is a multicollinearity between competences X1 and X2, X4 and X5, X6 and X7, X9 and X10, X8 and X11, X1 and X12, X2 and X12, X8 and X12, X11 and X12, X1 and X13, X2 and X13, X8 and X13, X11 and X13, X12 and X13, X7 and X15, X2 and X16, X17 and X18. That is, for them the condition $r_a \geq 0.7$. This is partly due to the presence of similar techniques to identify the same competence. In table 6 we show the elimination of multicollinearity.

Thus, X2, X5, X7, X8, X9, X12, X13, X17 are excluded.

We propose to devote the following competencies as variables: self-development, self-education (modification of the technique of V.I. Andreev), creativity (modification of the technique of N. Vishnevskaya), tolerance (modification of the technique of G.U. Soldatova, O.A. Kravtsovoy, O.E. Khukhlaeva, L.A. Shaygerova), communicative tolerance (modification of the technique by V.V. Boyko), readiness for risk (modification of the methodology of AM Schubert), motivation for success (modification of the methodology of T.Elers), management (modification of the methodology V.Smekala, M. Kucera), emotional intelligence (modification N. Hall techniques), ownership of ICT (authors profile), the promotion of the sustainable development concept (authors profile). All these variables turned out to be significant, and the results of the survey can be considered reliable.
Table 6. Justification of exclusion from consideration of competencies

| Variable designation | The value of the association coefficient with Y | Variables to be excluded |
|----------------------|-----------------------------------------------|--------------------------|
| X1                   | 0.63                                          |                          |
| X2                   | 0.58                                          | +                        |
| X3                   | 0.38                                          |                          |
| X4                   | 0.37                                          |                          |
| X5                   | 0.36                                          | +                        |
| X6                   | 0.49                                          |                          |
| X7                   | 0.45                                          | +                        |
| X8                   | 0.43                                          | +                        |
| X9                   | 0.30                                          | +                        |
| X10                  | 0.33                                          |                          |
| X11                  | 0.46                                          |                          |
| X12                  | 0.42                                          | +                        |
| X13                  | 0.43                                          | +                        |
| X14                  | 0.39                                          |                          |
| X15                  | 0.43                                          |                          |
| X16                  | 0.63                                          |                          |
| X17                  | 0.48                                          | +                        |
| X18                  | 0.56                                          |                          |

5. Conclusions
As a result, one of the main problems in the development of an expert system for assessing the critical competencies of workers in the agricultural sector should be the selection of variables. The analysis of scientific publications, statistical compilations, web reviews conducted by the authors shows the absence of not only data, but also tools for their evaluation. This led to the proposal to use modifications of the methods of psychology to assess the critical competencies. There grouped critical competencies taking into account the peculiarities of work in the agricultural sector, highlighting not only intellectual, educational, communicative, motivational-volitional, management, network interaction, but also ecological competencies, reflecting the promotion of the Sustainable Development Concept. The analysis of existing methods of psychology has shown the need for their adaptation to the purpose of the study and the need to develop questionnaires for assessing competencies in ICT ownership, lean production and the promotion of the Sustainable Development Concept.

A selective survey of agricultural workers using modified methods of psychology and developed questionnaires allowed us analyzing and eliminating multicollinearity among competences. Eight variables were eliminated. The authors propose to use the following competencies in the expert system: self-development, self-education; creativity; tolerance; communicative tolerance; risk appetite; motivation for success; management; emotional intelligence; ICT ownership; promotion of the concept of sustainable development.

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