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COMPETENCY CONCEPTS ANALYSIS IN THE SYSTEM OF COMPUTER MODELING OF EDUCATIONAL TASKS

Abstract. The article discusses the necessity of creating competency based tasks for computer educational models. This requires clarification of competency concept as well as the methods of its measurement. Several approaches to understanding competency and its definition have been analyzed.
It is obvious that the majority of those do not describe development of measurement instruments for competency levels. Some of the discussed approaches make it possible to split the competency into separate components and consider the activities leading to upgraded competencies.
The author provides definitions of competency and competency level. *Competency* is a mental construct which is a certain unity of a person's skills required within definite context of activity for a definite set of possible tasks. Competency always describes "unity of two" – 1) set of tasks in the context; 2) the performer.
Competency level is an index, characterizing the probability of successful performing of the task (on the given level) out of a definite set (variety) of tasks in the defined context by the definite performer. The experimental and indirect methods of competency measurement have been described.
It is possible to view the construction of the competency from two different points: which *parts (ingredients)* and which *components* it includes. *Parts (ingredients)* are knowledge, skills, behaviours, attitudes, etc. *Components* are minor competencies aimed to solve minor auxiliary tasks. Thus, in order to solve a competency task it is necessary to solve a few easier tasks which would complete some zones of competency.
The proposed approach describes the theory of competency level and structure measurement being a basis for competencies forming management. The mentioned approach requires more detailed development which is viewed as the matter of further research and publications.

Keywords: computer models; competency; competency level measurement; competency structure; competency elements; competency model.

1. INTRODUCTION

Problem statement. Competency-based education which is the key idea of the New Ukrainian School state policy and an important problem discussed in our Research work "The system of computer modeling of educational tasks for formation of Natural and Mathematical Sciences students' competencies" calls for clarification of the competency concept and analysis of its practical implementation.

Scientific literature analysis shows that the term "competency" is widely used within different contexts. It may be acceptable at the stage of analysis and discussion but is intolerable when it goes about competency measurement and management of competencies formation.

A definition of Competency-Based Education is provided in [1].

Competency-based education, also known as mastery-based, proficiency-based, or performance-based, is a school- or district- wide structure that replaces the traditional structure to create a system that is designed for students to be successful and leads to continuous improvement. In 2017, the National Summit for K-12 Competency-Based Education brought together 100 innovators in competency education to provide insight on emerging issues in the field of competency education [13]. At that meeting, participants fine-tuned a working definition of high quality competency education, which includes five elements:

1. Students advance upon demonstrated mastery.
2. Competencies include explicit, measurable, transferable learning objectives that empower students.
3. Assessment is meaningful and a positive learning experience for students.
4. Students receive timely, differentiated support based on their individual learning needs.
5. Learning outcomes emphasize competencies that include application and creation of knowledge, along with the development of important skills and dispositions.

Proper competency tasks development is impossible without clear competency definition and its measurement.

The article is aimed to analyze the existing concepts of competency and its practical implementation, work out the basis for the development of operational single/unified understanding of competency which would make it possible to measure it and manage the process of its formation.

2. RESEARCH RESULTS

As a single basis of analysis of competence concept implementation the following information is suggested for consideration: in which processes and how the term competency is used. For more precise analysis it is necessary to formulate the **hypothesis** which will be further verified in the process of literature analysis.

Hypothesis of understanding the competency phenomenon

According to the existing definitions competency is understood as a complex quality characteristic of a person, similar to the measurable indexes like height, weight, etc. In our research another approach to the definition of the competency is proposed.

Competency is a mental construct which is a certain unity of a person's skills required within definite context of activity for a definite set of possible tasks. Competency always describes "unity of two" – 1) set of tasks in the context; 2) the performer.

Competency level is an index, characterizing the probability of successful performing of the task (on the given level) out of a definite set (variety) of tasks in the defined context by the definite performer.

Thus, competency is not a person's quality but a mental construct. Previously, knowledge and skills were used to denote this construct, whereas now it is the matter of the competencies.

In this meaning we can speak about the competency only within the definite variety of tasks in the corresponding context. Further, unless stated otherwise, the tasks will be always taken within corresponding context. Let us assume that some variety of tasks {T} is defined. For each task there are levels (classes) of performance quality as well as correspondent criteria of correlation of task performing quality to the class. The number of classes of task quality performance will be the same for all the tasks in order to simplify the process. Thus, the competency level of a person on the set class of tasks can be defined as a probability of any task being performed out of the set variety on the quality level no lower than the set standard.

This probability can be defined both **experimentally** (to set the task and see the result of its performance) or **indirectly** (on the basis of some information about the performer and the tasks). Let's discuss both options more precisely.

*Defining task performance probability **indirectly**.*

All the variety of tasks is divided into the blocks of relatively equivalent tasks. A few tasks

are given out of each block of equivalent tasks. The part of successfully performed tasks on the set level is calculated. Thus, it is possible to define the probability of a task being performed on the necessary level for the definite performer. Such approach has some difficulties as it requires time and is hard to perform. If there are many tasks the process of their solving provides unconscious education of the performer.

Indirect defining of the probability can be performed in two ways:

1) First. Theoretical. To analyze all the knowledge, skills, behaviors, attitudes, etc. on the expert level, which are required to perform all the tasks out of variety {T} on the set level. After that, within the frames of correspondent mathematical or other model, it is necessary to combine the information about the person and the tasks with the probability of their successful performance.

2) Second. Empirical. Different people are given the tasks out of variety {T}; successfully performed tasks are noted. At the same time, it is necessary to collect the information about these people which can influence the result of task performance. Statistical analysis of results will enable to build the model of tasks successful performance prognosis on the basis of some information about the performer and the tasks.

It might seem to be quite difficult. But the level of difficulty can be regulated. The level of difficulty is defined by the balance between the precise description of variety of tasks and the desired accuracy of the result (quality) prognosis of their performing.
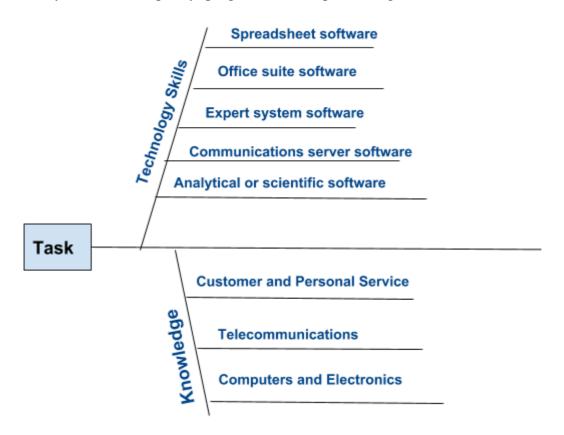

Fig. 1. Diagram of various factors influencing the successful task performance

Each task can be represented as a diagram (pic.1), showing the factors and the degree of their influence on the successful performance of a task. Knowledge, skills, values, attitudes -all the competency ingredients may be considered as these factors, specified for a certain level. Any task out of the variety {T} can be represented in terms of competency ingredients needed for its performance. For each level of task performance the criteria can be set in terms of competency ingredients availability. Thus, if all the tasks out of the variety are stated and the formed competencies' ingredients are defined, it is possible to calculate the level of a person's competency on the set variety of tasks. Alongside, the missing ingredients can be defined. This is our

understanding of competencies.

Before we analyze the existing definition and the practical implementation of the competency concept, it is necessary to make some queries in order to perform the analysis. These queries are:

1. Does the concept provide the quantitative measure of the competency level?
2. What is the processing time to create the instrument to measure the competencies of a definite person on the given set of tasks?
3. What is the processing time to measure the competencies of the definite performer with the definite instrument?
4. What is the correlation between the accuracy of competency level measurement, the processing time spent to prepare the measuring instrument and the procedure of measurement itself?

The analysis results are provided in table 1.

Table 1.

Summary table reflecting the results of analyzing different concepts of competency understanding and application

№ Concept	Does the concept provide a way of quantitative measurement of competency level?	Processing time to prepare measuring instrument	Processing time to measure the competencies	Accuracy of measurements
1	partially	not shown	not shown	not shown
2	no	not shown	not shown	not shown
3	no	not shown	not shown	not shown
4	no	not shown	not shown	not shown
5	no	not shown	not shown	not shown
6	no	not shown	not shown	not shown
7	no	not shown	not shown	not shown
8	partially	not shown	not shown	partially
9	no	not shown	not shown	not shown
10	partially	Partially	partially	partially
11	yes	Partially	partially	not shown

Analysis of the existing concepts of competency definition and implications

Concept 1. Competency Measurement Model [2].

A model for the Competency Mapping and Measurement is introduced. This approach allows obtaining information about the level of appropriateness of the skills associated with the different processes. These data make it possible, *inter alia*, to analyse the morphology of the business processes, to assess the staff, to better use and distribute the resources over the processes, to promote the mobility of the people across the firm and to optimize training activity and HR management.

Each competency must be associable and linkable to specific processes performed by a company and to individuals who are the owners of these competencies. Competency management has an important impact on improving the overall quality of the final product.

In the HR-XML Consortium Competencies Schema, a competency is defined as: A specific, identifiable, definable, and measurable knowledge, skill, ability and/or other deployment related

characteristic (e.g. attitude, behavior, physical ability) which a human resource may possess and which is necessary for, or material to, the performance of an activity within a specific business context.

Formula.

● **Competency**

○ [of which qualities of a person] knowledge, skill, ability and/or other deployment related characteristic (e.g. attitude, behavior, physical ability)

❖ [which are characteristics of these qualities] specific, identifiable, definable, and measurable

■ [what for] which a human resource may possess and which is necessary for, or material to, the performance of an activity within a specific business context.

A simplified taxonomy derived from the huge literature available on this topic groups competencies into three categories:

a) *Knowledge*. It concerns everything that can be learned from educational/formative systems and training courses and everything which involves cognitive processes (i.e. perception, learning, communication, association and reasoning). It represents the theoretical understanding of something such as a new or updated method or procedure, etc…

b) *Know-how*. It is related to personal experiences and working conditions. It is learned by doing, by practice, by experience. It is the practical knowledge consisting in "how to get something done".

c) *Behavior*. It is referred to individual characters, talents, human traits, or qualities that drive someone to act or react in a certain way under certain circumstances.

The following proficiency scale has been adopted to assess the Requested Competencies. These levels can be also used to identify the tasks performance level.

Table 2.

PROFICIENCY SCALE

0 - None; 1 - Limited; 2 - Basic; 3 - Proficient; 4 – Advanced; 5 – Expert

Proficiency Level	Description
1. Limited	Limited or no use of competency required for the job Competency has been minimally demonstrated May have had limited opportunity to apply the competency May have limited understanding of the competency
2. Basic	Basic understanding or knowledge needed for the job Basic understanding and knowledge sufficient enough to handle routine tasks Requires some guidance or supervision when applying the competency Understands and can discuss terminology and concepts related to the competency
3. Proficient	Detailed knowledge, understanding, and application of the competency Ability to handle non-routine problems and situations Requires minimal guidance or supervision / works independently Consistently demonstrates success in the competency Capable of assisting others in the application of the competency

4. Advanced	Highly developed knowledge, understanding, and application of the competency required to be successful in the job and organization (total mastery) Can apply knowledge outside the scope of one's position Is able to coach or teach others on the competency Has a long-term perspective Helps develop materials and resources in the competency
5. Expert	Specialist/Authority level knowledge, understanding, and application of the competency required to be successful in the job. Recognized by others as an expert in the competency and is sought out by others throughout the organization (expert in the area) Works across team, department, and organizational functions Applies skill across multiple projects or functions Able to explain issues in relation to broader organizational issues Creates new applications or processes Has a strategic focus

Conclusion for Concept 1. The suggested model describes the way how to measure the mismatch of the set of person's competencies with the roles in definite production processes. However, it does not demonstrate how to measure those competencies.

Concept 2. European qualifications framework [3].

The European Union addressed the question of defining 'competence' in the context of developing the European qualifications framework (European Parliament, 2008). In anticipation of an accepted definition, the project adopted a definition used in the earlier development stages of the European qualifications framework, which reflects a multifaceted understanding of both knowledge and competence. Propositional knowledge (knowing that), practical knowledge (knowing how) and procedural knowledge (knowing how to be) are all encompassed, and underpin development of a concept of competence that places priority on ethical and reflective practice. The question is raised of whether all competences are 'learnable', or whether staff selection systems should seek to identify innate characteristics essential for achieving competences. This is a question on which there is currently no consensus.

Earlier competence frameworks have brought different approaches to the distinction between core or compulsory, and specialised or optional, elements of competence. Development work undertaken within this project has identified foundation or transversal competences, which should be exhibited in all professional activities; client-interaction competences, prominent to the client as delivered directly in communication with them; and supporting competences, which ensure that the facilities, networks and resources needed for service delivery are in place.

The concept of competence applies not only to career guidance practitioners but also to the career self-management competences needed by citizens across the lifespan. Where such competences have been defined, they provide a useful benchmark for the design of career guidance services and of the staff competences needed to support clients' development of their own competences.

This study has adopted the following four-part definition of competence:

(a) *cognitive competence*, involving the use of theory and concepts, as well as informal tacit knowledge gained experientially;

(b) *functional competence* (skills or know-how), involving those things that a person should be able to do when they are functioning in a given area of work, learning or social activity;

(c) *personal competence*, involving knowing how to conduct oneself in a specific situation;

(d) e*thical competence*, involving the possession of certain personal and professional values.

Formula.
- **Competency**
  - [Competency component] cognitive competence, involving the use of theory and concepts, as well as informal tacit knowledge gained experientially;
  - [Competency component] functional competence (skills or know-how), involving those things that a person should be able to do when they are functioning in a given area of work, learning or social activity;
  - [Competency component] personal competence, involving knowing how to conduct oneself in a specific situation;
  - [Competency component] ethical competence, involving the possession of certain personal and professional values.

Conclusion for Concept 2. The competencies model for career guidance is described. There is no separate construction of the competency and no methods to measure the level of definite competence. On the example of this concept we can introduce two competency aspects. Those are *ingredients* and *components* of the competencies. More detailed description will be provided further.

Concept 3. Glossary of Terms for TVET, Assessment and Verification **[4].**

Competency is understood as the individual's ability to use, apply and demonstrate a group of related awareness, knowledge, skills and attitudes in order to perform tasks and duties successfully and can be measured against well-accepted standards (levels) required in employment as well as assessed against provided evidences at work location. The competency affects both individual's job responsibility and performance on the job and usually falls into two categories, namely technical and behavioral.

Formula.
- **Competency**
  - [Ability] individual's ability
    - [what to do] to use, apply and demonstrate
      - ❖ [what to use] group of related awareness, knowledge, skills and attitudes
        - [what for] to perform tasks and duties successfully
          - [which are characteristics of these qualities] which can be measured against well-accepted standards (levels) required in employment as well as assessed against provided evidences at work location.

Competency Element is the fundamental component or part or basic building block of a unit of competency (competence standard) that describes the key activities or elements of the work covered by a particular occupation / trade / job. Assessments are carried out at the element level according to the corresponding criteria for each. Here, the competency element is discussed as a part of work, but not as the way of competency detalization.

Standard of Competence is a performance specification describing what is expected of a person performing a particular work activity. It is expressed in elements of work together with performance criteria.

Conclusion for concept 3. It is stated that the elements of the competency must be *measurable* but the ways and the scales for measurement are not provided.

Concept 4. Tuning, 2000 [5].

Competencies represent a dynamic combination of cognitive and metacognitive skills, knowledge and understanding, interpersonal, intellectual and practical skills, and ethical values.

Formula.

- **Competency**
  - [What] a dynamic combination of cognitive and metacognitive skills, knowledge and understanding, interpersonal, intellectual and practical skills, and ethical values

Fostering these competencies is the object of all educational programmes. Competencies are developed in all course units and assessed at different stages of a programme. Some competencies are subject-area related (specific to a field of study), others are generic (common to any degree course). It is normally the case that competency development proceeds in an integrated and cyclical manner throughout a programme.

Conclusion for Concept 4. The process of competencies formation is described but there is no description of their measuring.

Concept 6. DeSeCo [6].

DeSeCo defines a **competency** as the ability to successfully meet complex demands in a particular context. Competent performance or effective action implies the mobilization of knowledge, cognitive and practical skills, as well as social and behavior components such as attitudes, emotions, and values and motivations. EU defines **competency** as a combination of knowledge, skills and attitudes appropriate to the context.

Let's list important ideas concerning understanding of the competency phenomenon.

What is a competency? A competency is the ability to meet a complex demand successfully or carry out a complex activity or task.

Components of competency. It is the demand, task, or activity which defines the internal structure of a competency, including the interrelated attitudes, values, knowledge and skills that together make effective action possible. Competencies cannot be reduced to their cognitive components.

Observing competencies. Competencies are manifested (or observable) in actions the individual takes in particular contexts and situations.

Formula.

- **Competency**
  - [What]the ability to successfully
    - [What to do] meet complex demands in a particular context

Conclusion for concept 6.

The concept of competency components is introduced. The mechanisms of competency level measurement are not shown. The inner structure of the competency is often discussed, which corresponds to the "ingredients" described in our article.

Concept 7. John Raven [7].

John Raven defines competency as a specific ability needed to perform a definite action effectively within a certain subject field, including expert knowledge, special subject skills, types of thinking as well as understanding the responsibility for the actions.

Formula.

- **Competency**
  - [What] a specific ability
    - [What to do] to perform a definite action effectively within a certain subject field, including expert knowledge, special subject skills, types of thinking as well as understanding the responsibility for the actions.

Majority of the researchers define the competency as not just the possibility to have knowledge, but be potentially ready to solve the tasks within the activity field.

Conclusion for concept 7. No information concerning measuring.

Concept 8. Competency as an integrated characteristic of a person [8,9].

In [9] it is stated that "the difficulty to create a competency based measuring instrument is defined by the fact that "competency/competence" can be described as an integrated characteristic of a person. According to many authors, knowledge and skills gained by the student in the process of studying are in this case just definite **structural elements** of the discussed attribute alongside with personal characteristics of the subject of education.

As the experience of technological development shows, the more complicated is the parameter being studied, the more complicated should be the measuring instrument. Accordingly, the competency based measurement instrument must be based on a certain set (complex) of instruments (indicators?) including psychodiagnostic and pedagogical (to measure the level of educational achievements) ones.

In [10] it is stated, "Modern epistemology and the cognitive science describe two main types of knowledge - declarative ("know that") and procedural ("know how"). Thus, the experience which the student obtains while performing educational research is a set of competencies which in this very case represent procedural knowledge. While the declarative knowledge is a set of statements concerning the objects within the subject field (factual knowledge), procedural knowledge is the list of operations, actions which must be performed in definite problem situation in order to reach the target.

Procedural knowledge can be estimated only on the basis of the activity results (whether the end product satisfies the aims, or whether the chosen algorithm was successful). Thus, the use of traditional testing technologies, namely the ones involving choice of a variant, cannot adequately assess formation of a person's behavior in a problem situation, and his/her research competency level in particular. In this case, the competency is understood as the right decision taking in the process of choosing the system of actions in order to reach the set targets (productive behaviour in the segment of subject field being studied).

Conclusion for Concept 8.

The complexity in competency measurement is caused by the fact that it is an integral feature. The executive competency part must be measured within the activity.

Concept 9. The Law of Ukraine "On Education" [10].

Competency is a dynamic combination of knowledge, skills, types of thinking, ideas, values, other personal qualities which defines a person's ability for successful socialization, performing professional or further educational activity;

Formula.

- ●**Competency**
  - ○ [What] dynamic combination of knowledge, skills, types of thinking, ideas, values, other personal qualities,
    - ■ [which] defines person's ability
      - ● [to do what] successful socialization, performing professional or further educational activity;

Conclusion for concept 9. The way to measure the competency is not mentioned.

Concept 10. The competencies schema [11].

The competencies schema is intended to capture information about measurable characteristics. Some competencies may be measurable, but nevertheless difficult to quantify. In some cases, the measure may be simply whether the characteristic exists or does not exist. Some competencies can be objectively measured, whereas others may only be subjectively recognized. Example: In the context of HR-XML's competency schema, education would be considered a competency when it can be quantified or when it is used as a measure for a given business purpose. An educational

degree may be evidence of a competency. Descriptive information about an educational degree – e.g., the location of the school or institution granting the degree – is not a competency.

- Competencies are related to performing an activity. Competencies can be thought of as a level of ability or characteristic useful or necessary for performing an activity.
- Competencies are attributes of a human resource. However, the model developed by the Competency Workgroup is generalized enough so that it might be applied to other entities, such as organizations.
- Competencies may include deployment-related characteristics such as "willing to relocate," "non-smoker," etc., but generally would not include purely demographic characteristics, such as sex, race, or religion.
- Competencies can be recursive. A competency may include other competencies. One competency might be decomposed into several component competencies, each of which might be separately measurable.
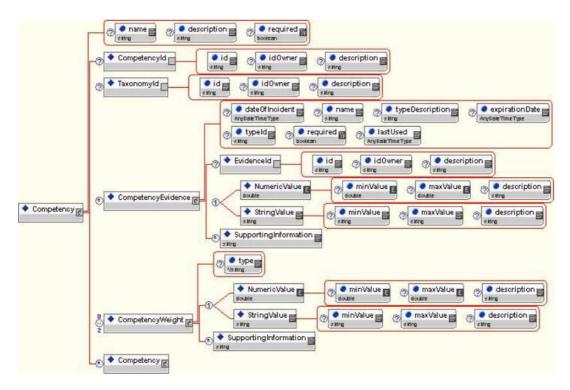

Fig. 2. Scheme of competency description

The Competencies schema is intended to be a fragment that can be incorporated within a wide variety of process-specific schemas. Among the range of processes the competencies schema may help support are:

- 360º Feedback (Evaluation by Peers)
- Other performance measurement instruments that measure competencies
- Competency Modeling (an expert service)
- Individual performance development planning and goal setting
- Performance monitoring & reporting
- Training curricula and individual courses that build competencies
- Career development systems
- Inventories of workforce competence (taxonomies for general and specialized uses)
- Selection procedures that assess competencies
- Succession planning systems
- Pay-for-competencies compensation systems

- Automated job descriptions
- Core competencies for strategic planning
- Psychometric (Personality) testing
- Recruiting

Conclusion for concept 10. Basics to measure the competencies are available.

Concept 11. Moodle - competencies [12]

Being the most widespread system of studying management in Ukraine and all over the world, Moodle uses the Module Référentiel de compétences as the most suitable competencies assessment instrument. It was created by Jean Fruitet, University of Nantes, France.

Each competencies repository has the following hierarchical structure:

Domain 1 (Code, description)
      Skill 1.1 (Code, description)
            Item 1.1.1 (Code, Description, Weight, Number)
            Item 1.1.2 (Code, Description, Weight, Number)…
      Skill 1.2 Code, description)
            Item 1.2.1 (Code, Description, Weight, Number)
            Item 1.2.2 (Code, Description, Weight, Number)
            Item 1.2.3 (Code, Description, Weight, Number)…
 Domain 2 (Code, description)
      Skill 2.1 (Code, description)
            Item 2.1.1 (Code, Description, Weight, Number)
            Item 2.1.2 (Code, Description, Weight, Number)… ...

Each competency (compétence) belongs to a definite field (Domain) and contains items. Fields, competencies and the items are identified with a short unique code (Code) and a longer description (Description) while the items have special characteristics – Weight, which reflects the importance (value) of this item in comparison with others, and the Number – minimum of studying activities, in which this item must be confirmed in order to be approved. Repository must at least contain one Domain, a Domain - one competency and the competency - at least one item. Teachers assess only the items. On the basis of this assessment, a conclusion concerning each competency confirmation is calculated automatically, as well as concerning the field and repository in general. The rules of conclusion making and summing up are described in the Protocol where there is an option to set any number of such criteria:

- compulsory items, competencies and domains must be confirmed, otherwise the competency, the domain or repository it belongs to will not be confirmed;
- minimum number of confirmed items, competencies and domains may be set for each competency, domain or repository, which will not be considered as confirmed without the competency;
- threshold value of competency, field or repository confirmation is a minimal sum of values of confirmed items which is necessary to confirm the competency, domain or repository. If the item Number is more than one, its value is added so many times as it is confirmed in different studying activities. In order to confirm each competency, domain or repository all the set criteria must be satisfied and completed.

Conclusion for concept 11. The above mentioned concept represents the mechanism of competency level calculation on the basis of studying and other activities confirmation. The drawback of such approach is "randomness" within correlation of *items* and *competencies*, as well as absence of clear definition of competency.

All these conceptions do not give an answer to a question "Is it possible or how can we construct competency consequently?" In other words, is it possible to describe the competency

structures so that it would be clear what the difference is if we compare two competent people having almost the same level of competency.

Further described approach of competency understanding allows us to perform its measurement, comparison, and the management of its forming process.

Competency is defined on the multiplicity of tasks. Assuming, a person is competent at X level with B probability within $\{T\}$ multiplicity of tasks on the condition that he/she solves any task out of that variety $\{T\}$ no worse than at X level, with B probability.

According to the provided definition, the competency level can be experimentally defined in a following way.

Let's take a random subset of tasks $t_i \in \{T\}, i = 1..N$ out of multiplicity of tasks on which the competency will be defined. After that the performer receives these tasks. The next step is marking the level on which he/she managed to complete the tasks. Next, count b as part of the tasks completed at the level $x_i \geq X$. Then, if $b \geq B$ we can say that the performer is competent at the level X with B probability within $\{T\}$ multiplicity of tasks. Let's note it as $C_i = (X, B, \{T\})$ Competency of any (i) performer on multiplicity $\{T\}$ is at level X with the probability B.

Competency construction. It is possible to view the construction of the competency from two different points: which *parts (ingredients)* and which *components* it includes.

Parts (ingredients) are knowledge, skills, behaviours, attitudes, etc.

Components are minor competencies aimed to solve minor axillary tasks. Thus, in order to solve a competency task it is necessary to solve a few easier tasks which would complete some zones of competency.

Example. A car consists of certain details (ingredients), apart from which there are also construction joints of the engine, wheels, frame, electronics, security system, etc. (components). Unlike a car, one and the same ingredient of the competency can be present in different components simultaneously, in various ways and volume (amount).

For each testee, it is possible to draw a table. Down - *ingredients* and the levels of their formation are displayed. Across - the *components* and the levels of their formation are shown. The crossing points indicate the extent the definite ingredient is needed in correspondent component forming as displayed in Table 3. More precise discussion will be provided in further publications.

Table 3.

Correlation of ingredients realization levels and their importance in subcompetencies

		components	Sub Competence 1 $\{T1\}$	Sub Competence 2 $\{T2\}$	Sub Competence 3 $\{T3\}$
	ingredients	**level**	$C1_i = (X1, B1, \{T1\})$	$C2_i = (X2, B2, \{T2\})$	$C3_i = (X3, B3, \{T3\})$
1	Knowledge 1	**6**	$a_{1,1}$	$a_{1,2}$	$a_{1,3}$
2	Knowledge 2	**3**	$a_{2,1}$	$a_{2,2}$	$a_{2,3}$
3	skills 1	**6**	$a_{3,1}$	$a_{3,2}$	$a_{3,3}$
4	behaviours 1	**7**	$a_{4,1}$	$a_{4,2}$	$a_{4,3}$

It is possible to build multidimensional space connecting competency *ingredients* with the probability and the level of task performing.

In this space for each task and given X and B it is possible to single out multiplicity of points (ingredients of competency) which guarantee the completing of the task at X level with B probability. Those are marked with red in the picture. For example, Knowledge $\{1\}$ must be at the level 7, and Knowledge $\{2\}$ on the level 9. If the component is marked with 0 sign, this one is not needed to complete the task. To be more precise it is necessary to speak about minimum required set of ingredients.
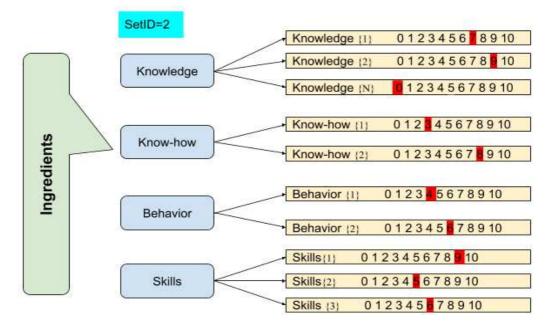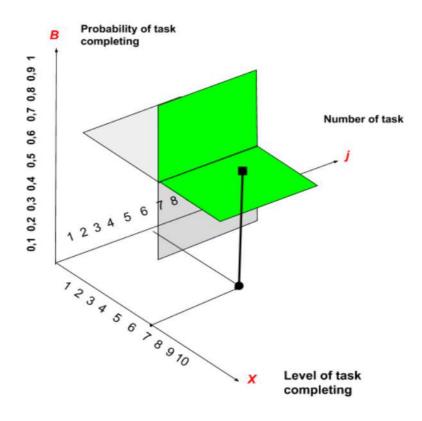
Fig. 3. Example of ingredients set and levels necessary to complete the task

Picture 3 shows the example of a definite set of ingredients. It lists both the ingredients names and the levels of their mastering. SetID means a unique set of ingredients.

Each definite set of task components can be marked with a unique number, e.g. Set {j}. Assuming, the task $t_i \in \{T\}$ is chosen and the SetID of ingredients is given as well as the level of required task performance X=6. Then, the following graph can be drawn:

Pic.4. Results of task completing (level and probability) for the given set of ingredients SetID

The following axes are represented on the graph. The axis **J** of tasks displays the number of tasks out of the multiplicity. The axis **X** is a level of performance and the axis **B** is a level of

probability. How do we mark points on this graph? **M** of performers is chosen, satisfying the requirements of the certain SetID of the competency's ingredients components SetID. Everybody is given Task 1. The part of performers who completed the task at each level is marked. Accordingly, the probability of this task completing is set for each level, as the correlation of those who completed the task at this level. The green spaces in the picture section the area, in which the tasks are performed with the defined (B) probability on the level not lower than (X). (pic.4)

Let us assume that for some sets of ingredients Set {j} the corresponding tests are done and the similar graphs are drawn (collected data). This data can be shown in table 4:

Table 4.

Head of the table "Correlation of tasks completing level and sets of ingredients"

SetID of ingredients	Probability	Level	Task number

If these data are available, then, the following can be done:

1. For a certain set of ingredients Set {j}, the level of performance and the probability of the correspondent tasks can be selected, e.g. for the person with ingredients set Set {j} - a set of tasks within his/her competency can be selected.

2. Choose the tasks on the edge of the competency (the tasks are to be a bit below competency level). This is a development zone for a person with the ingredient set Set {j}.

3. Comparing ingredients sets Set {j} for a definite task $t_i \in \{T\}$, a minimum ingredients set necessary to complete the task at the required level can be specified.

4. After step 3 it is possible to define a correspondent Set {j} of ingredients for any set of tasks (field of competency).

5. Ingredients rate can be created within the set of ingredients for a certain multiplicity of tasks, according to their crucial value. This allows planning of competency development on the basis of the set of tasks, and afterwards creating a detailed list of competency components.

5. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

1. A specified competency model is presented for implementation, having been developed as a result of competency-based education at the New Ukrainian School, as well as Research work "The system of computer modeling of educational tasks for formation of Natural and Mathematical Sciences students' competencies".

2. **Competency** is a mental construct which is a certain unity of a person's skills required within a definite context of activity. **Competency level** is an index, characterizing the probability of successful performing of the task (on the given level) out of a definite set (variety) of tasks in the defined context by the definite performer. Competency always describes "unity of two" – 1) set of tasks in the context; 2) the performer. Thus, competency is not a person's quality but a mental construct. Previously, knowledge and skills were used to denote this construct whereas now it is the matter of the competencies.

3. Competency is defined on the multiplicity of tasks. A person is competent at *X* level with *B* probability within {**T**} multiplicity of tasks on the condition that he/she solves any task out of that variety no worse than at *X* level, with *B* probability.

4. It is possible to build multidimensional space connecting competency ingredients with the probability and the level of task performing.

5. In this space for each task and given *X* and *B* it is possible to single out multiplicity of points (ingredients of competency) which guarantee the completing of the task at *X* level with *B* probability.

6. Crossing points of such multiplicities for all the tasks create the multiplicity of competency ingredients of the given tasks as well as X and B.

7. In competency tasks development it is necessary to consider the point of including all the

attributes out of multiplicity of competencies. Thus, the way of competency tasks construction can be drawn.

8. Dynamic combination can be understood as a necessity to apply different competency ingredients to solve different tasks.

9. It is necessary to consider interconnection (synergy) of some competency's ingredients. As a rule, synergy can increase the X and B results. The phenomenon of competency's ingredients synergy requires further research.

10. Special attention must be paid to the necessity of not just learning but unlearning (concerning the skills, in particular). The process of unlearning may be necessary to increase the competency.

11. The existing competency based approaches to education management require improvement but still can be implemented.

12. The proposed model is a theoretical basis for competency measurement and the strategy of its forming. Yet, the model is not enough developed for its practical implementation. A certain follow-on revision and detailed specification are required, which are supposed to be a subject matter of further publications.

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АНАЛИЗ КОНЦЕПЦИЙ КОМПЕТЕНТНОСТИ В СИСТЕМЕ КОМПЬЮТЕРНОГО МОДЕЛИРОВАНИЯ УЧЕБНЫХ ЗАДАЧ

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Аннотация. Первопричиной написания статьи является необходимость научиться создавать компетентно ориентированные задания для компьютерных учебных моделей. Для этого необходимо уточнить понятие компетентности и методов ее измерения. Проанализированы различные подходы к пониманию и определению понятия компетентности. Определено, что большинство рассмотренных подходов не определяет путей к построению средств измерения уровней и структуры компетентностей. Некоторые из рассмотренных подходов позволяют детализировать компетентности на отдельные компоненты и учитывать деятельность, приводящую к росту компетенций. Предложено авторское определение понятия *компетентности* и *уровня компетентности*. *Компетентность* - ментальный конструкт, который определяет перечень умений, необходимых для успешного выполнения задач из определенного множества в определенном контексте. *Уровень компетентности* – число, обозначающее вероятность успешного выполнения задач (на определенном уровне) из заданного множества задач в определенном контексте конкретным исполнителем.
Рассмотрены экспериментальный и опосредованный способы измерения компетентностей.
Предлагается рассматривать конструкцию компетентности с двух точек зрения: какие *части (ингредиенты)* и какие *компоненты* она включает. *Части (ингредиенты):* знания, умения, поведение, отношение и т. *Компоненты* - небольшие компетентности, предназначенные для выполнения промежуточных задач. Так для решения определенной задачи обычно необходимо решить несколько более простых задач, которые определяют зону компетентности.
Предложенный подход описывает теоретический путь к измерению уровня и структуры компетенций. Также на основе этого подхода можно управлять процессом формирования компетенций. Отмечается, что данный подход требует детализации и дальнейшего развития. Авторы планируют это сделать в следующих публикациях.

Ключевые слова: компьютерное моделирование**;** компетентность; измерение уровня компетентности; структура компетентности; ингредиенты компетентности; модель компетентности.

АНАЛІЗ КОНЦЕПЦІЙ КОМПЕТЕНТНОСТІ В СИСТЕМІ КОМП'ЮТЕРНОГО МОДЕЛЮВАННЯ НАВЧАЛЬНИХ ЗАВДАНЬ

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Анотація. Першопричиною написання статті є необхідність навчитися створювати компетентнісно орієнтовні завдання для комп'ютерних навчальних моделей. Для цього необхідно уточнити поняття компетентності і методів її вимірювання. Проаналізовані різні підходи до розуміння і визначення поняття компетентності. Визначено, що більшість розглянутих підходів не визначає шляхів до побудови засобів вимірювання рівнів та структури компетентностей. Деякі з розглянутих підходів дозволяють деталізувати компетентності на окремі компоненти і враховувати діяльності, що призводять до зростання компетентностей. Запропоновано авторське визначення поняття компетентності і рівня компетентності. Авторами запропоновано визначення *компетентність* і *рівень компетентності. Компетентність* - ментальний конструкт, що визначає перелік умінь, необхідних для успішного виконання завдань певної множини у визначеному контексті. *Рівень компетентності* – число, що позначає вірогідність успішного виконання завдань (на певному рівні) з заданої множини завдань у визначеному контексті визначеним виконавцем.
 Розглянуто експериментальний та опосередкований способи вимірювання компетентностей.
Пропонується розглядати конструкцію компетентності з двох точок зору: які *частини (інгредієнти)* та які компоненти вона входять до її складу. *Частини (інгредієнти):* знання, вміння, поведінка, ставлення тощо. *Компоненти* - це менші компетентності, призначені для виконання проміжних завдань. Так для вирішення певного завдання зазвичай необхідно вирішити декілька більш простих завдань, які визначають зону компетентності. Запропонований підхід описує теоретичний шлях до вимірювання рівня і структури компетентностей. Також на основі цього підходу можна управляти процесом формування компетентностей. Відзначається, що даний підхід потребує деталізації та подальшого розвитку. Автори планують це зробити в наступних публікаціях.

Ключові слова: комп'ютерне моделювання; компетентність; вимір рівня компетентності; структура компетентності; інгредієнти компетентності; модель компетентності.