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INTEGRATED DEVELOPMENT OF FUTURE ENGINEERS' PROFESSIONAL AND COMMUNICATIVE COMPETENCE

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Abstract. The present article is devoted integrated development of professional and communicative competence of future engineers. The importance of paying attention to integration of competencies in the process of teaching LSP to future engineers has been grounded. A model of integrated development has been suggested. The article also includes examples of exercises and classroom activities that can be used in the language classroom for integrated development of competencies. The description of the model is followed by the results of its experimental testing. It has been proved that integrated development of competences makes language learning more effective. On the other hand, integrated development of competencies in the process of LSP teaching helps to improve the learners' professional knowledge and skills.
Keywords: competency-based education; engineering education; communicative competence; professional competence; teaching and learning system; language for specific purposes.

Introduction

The ideas of competency-based education, which began to gain popularity more than ten years ago, still determine goal setting, content selection and the choice of methods and techniques of teaching and learning. The most significant researches devoted to competency-based approach and the concept of competence in education and business belong to Boyatzis (1982), Spencer and Spencer (1993), W. Rothwell and P. Gerity (2004), J. Winterton, Le Deist & Stringfellow (2006), Rainsbury, Hodges, Burchell, & Lay (2002), Zimnyaya (2003), Khutorskoy (2005), V. Baydenko (2006) and other authors. Their works contain detailed descriptions of the concept of competence and different classifications of competences. Competences are usually grouped according to their functions and spheres of life in which they may be used. The presence of such a great number of researches shows that contemporary pedagogy is at the stage of analysis and differentiation of competences. In the nearest future this stage will be naturally replaced by synthesis and integration of competences [1].

The integration of competences has not been studied for a long time. According to researchers, the main problems of integrated development of competences are as follows: the description of integrated competence, selection of methods and techniques of teaching, content selection and developing ways of evaluating integrated competences [2].

In the context of globalization and in the information-based environment, the usefulness of learning languages has become of vital importance. The goals and means of language learning and teaching, however, continue to be hotly discussed. Modern engineering education requires taking into account relationships between separate competencies, because the learner's future career depends on the ability to communicate in English with specialists.

It goes without saying that communication is more than knowing a foreign language. Modern researchers, for example S. Gural [3], draw the attention of foreign language teachers to the links between the language, material objects of the surrounding world and the inner life of a personality.

Engineering communication involves not only linguistic and cultural aspects but also the professional one. In order to convey information in a foreign language engineers must understand its subject, which involves professional knowledge and skills and the ability to use all this for communicative purposes. Therefore, it is important to have a system of competences instead of a set of separate skills and abilities.

It follows from the above-mentioned facts that the problems of integrated development of competences are very important. Modern engineering education requires taking relationships between separate competencies into account. Only in this case the learners will have a system of competences instead of a set of separate skills and abilities.

The subject "Language for Specific Purposes" belonging to both professional and language education of future engineers creates opportunities for integrated development of different competences important for working and conducting research in engineering. Therefore, it is necessary to consider this subject as an integral part of engineering education. This means that when teaching LSP to future engineers the teachers should not only form the students' communicative competence but also integrate it with other competences of a modern engineer.

The present research is focused on integrated development of professional and communicative competences of future engineers.

Research Methodology

Research Objectives

The objectives of this research are to analyze the modern approaches, principles, methods and techniques used for teaching Language for Specific Purposes; estimate their efficiency with regard to competency based education фтв create a teaching and learning model aimed at the development of integrated engineers' professional and communicative competences.

Methods

The analysis of literature devoted to the problems of competence development helps us to figure out what approaches, methods, techniques and

tools may be used for integrating competences, to select those that can be used in LSP teaching and to specify and modify them in accordance with our research goal.

The method of comparison is used to compare and contrast traditional LSP teaching and learning and a system aimed at integrated development of competences.

The modeling method enables us to give a visual representation of a teaching and learning system for integrated development of competences.

At the final stage of our research, we do some experimental work which involves testing tasks designed for integrated development of future engineers' professional and communicative competence.

Model Description

Let us represent a teaching and learning system of integrated development of competences as an input-output model. The model is shown in figure 1.

The system of integrated development of professional and communicative competences is presented as interaction between the teacher and the learners aimed at achieving the goal. This process of interaction is determined by a number of principles and requires appropriate conditions. Approaches, principles, methods and conditions of teaching and learning are shown in corresponding blocks.

Structural elements of the system are presented as steps on the way from the goal of teaching to its result.

The goal of teaching is to develop professional communication competence of future engineers as an integrative unity of their professional and foreign language competences. It is important to note that this integrated competence must include not only communicative skills and abilities but also certain components of professional competence necessary for effective professional communication.

In order to achieve the goal it is necessary to select the content of teaching, choose appropriate methods and techniques and create appropriate conditions.

Besides, we think that the system should also contain the so-called functional components, namely gnostic, predictive, designing, organizational, communicative, constructive and evaluative [4]. They are closely connected with structural components. In figure 1 relations between elements of the system are shown by means of arrows. It is obvious that the model represents a simplified version of the teaching and learning system. For example, the diagram does not have information about teaching aids. The notion of method is presented in its broadest sense, as a principal direction in language teaching. It is implied that all these elements are included in the correspond-

ing blocks of the system and should be taken into account in the process of teaching.

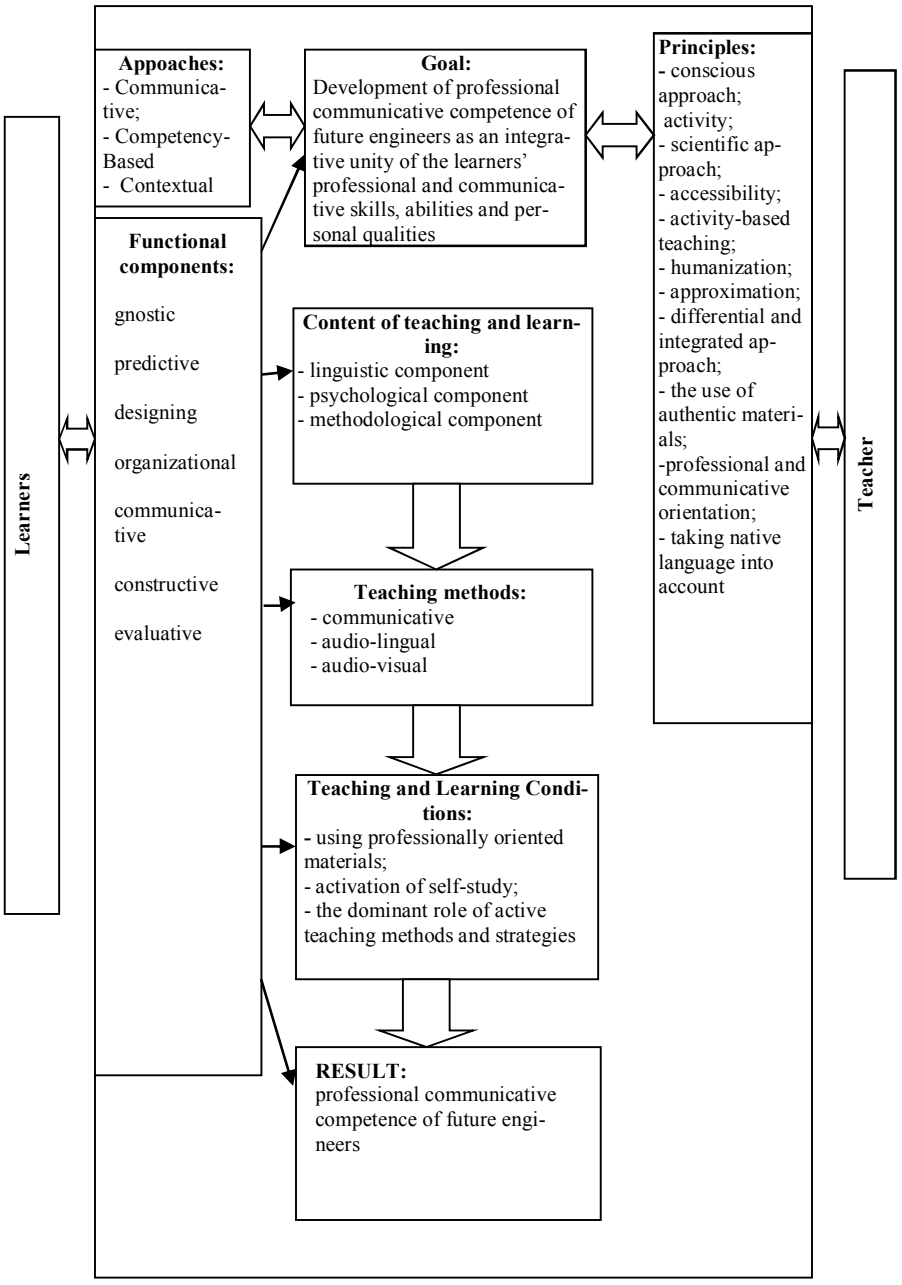

Fig. 1. The model of integrated development of future engineers' professional and communicative competence

Experimental testing

The next stage of our research is evaluation of the effectiveness of our teaching and learning system.

To test the model we chose a group of 15 students of the Department of Physics and Technology of TPU majoring in Physics of Kinetic Phenomena. In the previous semester the students had been taught the module 'Nuclear Physics'. Average score for the credit test in the fall term was 29,75 points out of 40. The written part of the credit test included such aspects as 'listening', 'reading', 'use of English' and 'writing', which involved describing a physical process in a written form. The oral part involved delivering a presentation on one of the problems of nuclear physics and answering questions. These task were aimed at checking the students' knowledge of nuclear physics and their ability to discuss issues related to this science. Students could be given a maximum of 10 points for each aspect.

Average scores for each aspect are shown in table 1. We also find it necessary to include the highest and the lowest result for each part of the credit.

Table 1

Credit test results in the fall term

	Multiple choice quiz (max 10)	Writing (max 10)	Presentation (max 10)	Answering questions (max 10)	Total score (max 40)
Average score	6.4	7.3	8.2	6.5	29.8
The highest score in the group	6.8	8.7	10	8	36
The lowest score in the group	6	4.7	6.7	5	22

In the spring term we organized the process of teaching and learning in accordance with our model. The main ideas of competency-based, contextual and communicative approaches were taken into account. The process of teaching and learning was based on the main principles indicated in the model: approximation, scientific approach, accessibility, activity-based teaching, etc.

To fulfill the condition of using professionally-oriented materials we chose the module 'Isotope separation' which met real professional needs of the students. They are trained to work at isotope separation plants, therefore, their professional communication will most likely belong to this sphere. The main teaching aid was the course book "English for Isotope Separation Studies" created by the authors for teaching foreign language communication in this field [5].

Here are some examples of tasks that were used for integrate development of future engineers' competences:

An exercise used at early stages of working on new material may be as follows:

Decide what the following definitions mean/Underline the words which mean the following:

- an isotope which was produced by the decay of a radioisotope, but which itself may or may not be radioactive *(radiogenic isotope)*;
- the time required for one-half of a given material to undergo chemical reactions; also, the average time interval required for one-half of any quantity of identical radioactive atoms to undergo radioactive decay *(half-life)*;
- an isotope with an unstable nucleus *(radionuclide)*;
- the process by which heavier chemical elements are synthesized from hydrogen nuclei *(nuclear fusion)*.

From the point of view of language teaching this task is useful for learning and remembering new terms in the foreign language. On the other hand, the learners have to use their knowledge of the subject. Therefore, the term will be understood and remembered together with its meaning.

Then the students did the tasks aimed at developing speaking, reading or listening skills in the process of working with new vocabulary. They were allowed to use different prompts. Although such activities cannot be regarded as communication, they encourage the students to use their professional knowledge. In some cases students even have to find necessary information in authentic sources.

Here are some examples of exercises used at this stage:

Match isotope separation techniques with the equipment they use. Then tell about these techniques using the prompts below.

1) gaseous diffusion	a) gas centrifuge
2) electromagnetic separation	b) diffuser
3) centrifugation	c) calutron
4) fractional distillation	d) column

Put the phrases below into the correct order and describe the process of making heavy water:

a) about 3% solution of NaOH;
b) electrolysis is carried out;
c) water formed is returned to the first stage cell;
d) water that is fed to 2nd stage cells;
e) nearly 99% of heavy water is obtained;
f) the distillate is further electrolysed.

When the students learned the foreign terms denoting main notions within a certain professional topic, we gave them tasks involving participation in complex communicative activities, such as communicative situations,

presentations, discussions, debates, role plays, process etc. Such exercises contribute to the development of communicative abilities. At the same time they help to develop competences needed for solving professional problems. For example, when preparing and delivering a monologue on the following problem *'You are a workshop foreman. Give the employees instructions on how to behave in case of a toxic gas leak'* the students develop their speaking skills. On the other hand, this task helps to form an important professional competence, namely ability to protect personnel and population in emergencies [6].

Three topics related to the problems of isotope separation were covered during the term.

We also changed the rating list so the students got more points for complicated communicative activities and for self-study. The independent work included reading of authentic scientific articles about isotope separation methods and doing interactive tasks in LMS MOODLE. Some of the students also prepared reports for scientific conferences. Such tasks helped to take the students' individual needs, interests and preferences into account, which is a very important part of both communicative and contextual approaches. All the exercises done in the classroom or at home were aimed at integrated development of competences.

The students' knowledge and skills were tested at the examination which was quite similar to the credit test in the fall term. The maximum number of points was 40. Although the tasks had the same format as the ones in the fall term, they were also designed to check integrated professional and language knowledge and skills. For example, the gap-filling task in the 'Use of English' section was aimed at checking the knowledge of not only topical vocabulary and special terms but also of some specific scientific facts. In the 'Writing' section the students had to write a description of a flow sheet showing a uranium enrichment technique and it was necessary to understand the nature of physical processes underlying the method.

The final presentation included the description of a real scientific research. It is important to mention that students of other groups also delivered presentations but those ones were based on a literature review.

The results we obtained are presented in the table below.

Table 2

Spring term examination results

	Multiple choice quiz (max 10)	Writing (max 10)	Presentation (max 10)	Answering questions (max 10)	Total score (max 40)
Average score	7.6	8.6	8.8	8.3	35.7
The highest score in the group	8.6	9.1	10	10	39
The lowest score in the group	6.5	5	6.8	7	27

The table shows that students got higher scores for all parts of the examination. Changes in average and the highest scores were the most significant. The students greatly improved their scores for answering questions on professional topics studied during the semester. Therefore, we can make an assumption that integrated development of competences helps the learners to deepen their professional knowledge.

Let us compare these examination scores with the results obtained in another group. The control group comprised future specialists in Electronics and Automation of Nuclear Plants who had also studied the module 'Nuclear Physics' in the fall term and showed similar results at the credit test. In the spring term they studied module "Electronics". When working with this group we used mainly traditional teaching methods and paid little or no attention to the integration of competences. Average scores of both groups are shown in the table below.

Table 3

Comparison of examination results in the experimental and the control group

Experimental group		Control group	
Fall term	Spring term	Fall term	Spring term
29.8	35.7	29.1	31.8

It can be seen that students from control group also improved their results, which is natural because traditional methods of teaching also give certain results. However, the difference between the scores was twice greater in the experimental group than in the control one.

Although the experiment showed that our teaching and learning system has certain advantages, it was conducted over a short period of time and involved few students. Therefore, further experimental studies are needed to prove the effectiveness of the system. We are planning to test it on groups of other engineering specialties.

Discussion

Experimental results allow us to assume that that organizing the teaching and learning process in accordance with the model helps to integrate the students' competences. Let us consider different elements of the teaching and learning system in more detail from the point of view of their contribution to integrated development of competences.

The content of education includes components, namely linguistic, psychological and methodological. The linguistic component is closely connected with the concept of professional discourse, which includes the foreign language and its functioning together with cultural and professional aspects. L. Minakova el al. [7] show that different categories of professional dis-

course reflect different aspects of professional communicative competence. Therefore, in the process of creating and understanding different forms of professional discourse the students are encouraged to combine their professional knowledge and language skills. The psychological component involves the development of future engineers' ability and willingness to take part in professional communication. The methodological component includes making the students familiar with different learning techniques and strategies and developing certain skills (goal setting, planning, effective time management). All this corresponds to such ideas of the competency-based approach as lifelong learning, development of information competencies and personal qualities needed to succeed in professional communication.

The choice of teaching methods also helps to integrate competences. In our case the communicative method allows the teacher to create situations in which students solve professional problems by communicating in a foreign language. The audio-lingual and audio-visual methods are of secondary importance but may be useful at certain stages of teaching process. The former is used for teaching the students to pronounce professional terms and the latter may help to teach the students professional concepts by means of visual aids (it may be especially useful when it is difficult for the language teacher to give a detailed explanation of a concept, process or phenomenon).

It is also very important to create favorable conditions for integrated development of competences. A ver important condition is the dominant role of active teaching methods and strategies. Discussions, role plays, problem solving are good communicative exercises. At the same time, they help to develop different academic and professional skills and abilities. Another condition is activation of self study. By this we mean that a substantial part of work should be done by the students outside the classroom. When working independently, the students learn to work with information sources, develop their reading and writing skills, enlarge their vocabulary and deepen their professional knowledge. The third condition is the use of professionally oriented materials.

There are also a number of important elements which determine the effectiveness of teaching and learning. These are approaches and principles of teaching.

Nowadays the competency-based approach is the basis of both engineering education and language teaching. We must follow the main principles of the communicative approach because practical application of the language is more important for technical students than linguistic knowledge. Besides, this approach makes it possible to use different types of tasks and teaching strategies, which is important for creating situations imitating real professional communication of engineers. The contextual approach is based on A. Verbitsky's [8] idea that typical professional activities should be modeled in educational process. In our system this approach determines the selection of content and ways of organizing the process of teaching and learning.

One more important block of our model comprises the principles of teaching and learning. Some of them, for example conscious approach, professional and communicative orientation, differential and integrated approach, etc. are always taken into account when teaching foreign languages. Other principles must be interpreted in a special way with regard to integrated development of competences. For example, materials used in the process of teaching must be authentic not only in terms of the language. They must be created by engineers or scientists for other people working in a particular field.

Although further experimental studies are needed to prove that the model can be universally implemented in educational process, the results we have to date allow us to make a conclusion about its high potential. We claim that organizing the process of language teaching in accordance with the model makes LSP acquisition more effective because language skills and abilities are developed in close connection with professional ones.

Conclusion

A teaching and learning system for integrated development of competences has been presented as an input-output model. Its effectiveness has been tested for one semester. The results of testing show that integrated development of competences makes language learning more effective. One more advantage of the system is that language teaching based on approaches, principles, methods and techniques included in the model helps to improve the learners' professional knowledge and skills.

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