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THE FORMATION OF INTELLECTUAL MOBILITY OF ENGINEERING STUDENTS THROUGH INTEGRATION OF FOREIGN LANGUAGE EDUCATION AND PROFESSIONAL TRAINING

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In the world of rapid changes, the concept of mobility is becoming an essential development factor for professionals, and understanding of this concept is not limited to physical mobility, i.e. studying and working abroad. Among various dimensions of mobility (academic, social, professional, cultural, etc.) we distinguish intellectual mobility as a characteristic of a professional and consider the problem of formation of intellectual mobility of engineering students through the integration of foreign language education and professional training. On the basis of theoretical research and practical experience, we have determined the pedagogical conditions for the formation of this characteristic in a technical university: 1) use of interactive teaching methods as well as ICT to change the function of a teacher when he/she becomes the moderator of students' intellectual activities; 2) development of students' motivation for intellectual activity by considering their psychological characteristics; 3) integration of foreign language education and professional training, active use of distance learning courses and intellectual games. The effectiveness of these pedagogical conditions while teaching ESP at Igor Sikorsky Kyiv Polytechnic Institute has been checked through carrying out the pedagogical experiment and set of questionnaires and tests to define the level of intellectual mobility. As a result, we have developed scientific and practical recommendations at administrative, methodological and practical levels for teaching staff. The development of teaching complexes to ensure the process of formation of intellectual mobility of specialists in the educational environment of a modern technical university has been proposed to be a prospective direction for scientific research.

Keywords: intellectual mobility; technical university; educational environment; pedagogical conditions; interdisciplinary integration.

Introduction

Modern developments in technology and socioeconomic changes together with intensive information flows stimulate pedagogical theory and practice to greater efforts in looking for effective ways to develop intellectual abilities and personal qualities of an engineering student. Requirements for the professional training of the 21st century engineers have been developed under the auspices of UNESCO with the participation of such reputable international organisations as European Federation of National Engineering Associations (FEANI), World Federation of Engineering Organizations (WFEO), and American Council for Accreditation in Engineering Sciences and Technology (ABET). These organisations develop standards for assessing levels of professionalism and ensure the mobility of engineers.

The purpose of a modern technical university is to train the intellectual, creative elite that, in addition to analytical and organisational knowledge, can develop new technologies, use foreign languages in a multicultural environment as well as quickly change the types and forms of intellectual activities without decreasing the effectiveness. The basis for the education system in the 21st century is human priority, and the key task is the development of thinking focused on future.

As early as the end of the 20th century, while considering the interdependence of the information age and intellectual development, the famous futurologist Toffler (1980) argued that by deeply changing the infosphere, people must also change their own mind – how they think about the problems, synthesise information, and how they anticipate the consequences of their actions. The scientist notes that professional competence depends on the high level of intellectual mobility because while accelerating in a society, the changes cause parallel acceleration in people themselves.

Labour market requires engineers that are able to independently use knowledge in non-standard, constantly changing situations ensuring the transition from a knowledge society to a society of competent citizens. Therefore, the problem of training intellectually mobile future professionals is topical for the whole world community.

The research on intellectual mobility is directly related to sociological and economic studies of mobility (Geuna, 2015), the issues of intellectualisation of professional training (Yegorova, 2005) and ensuring academic (Streitwieser, 2012) and engineering mobility in the world (Greenwood, 2011). A number of scholars have studied pedagogical conditions under which it is possible to develop various types of mobility

as a characteristic of students (Khorunzha, 2009; Nieliepova, 2011). Among pedagogical studies, there are those that consider foreign language education as a means to form professional mobility (Merkulova, 2008).

The interest in the issue of intellectual mobility, first of all, is connected with the change in understanding of the concept "mobility" which is considered by Michel (2010) not only as movement, motion, but also as a characteristic of readiness of an individual to changes throughout the life. One can observe a shift in the meaning of "intellectual mobility": from the interpretation of this notion as intellectual migration and exchange of thoughts and ideas to understanding of it as a personal quality, which becomes the basis for mobility of an individual and can manifest itself in different spheres of life (Mikhnenko, 2015).

We specify the concept "intellectual mobility of a future engineer" and define it as an integrated characteristic of a personality that ensures his/her readiness to find, process and effectively apply increasing information flows, to produce new ideas and perceive innovations with tolerance; promptly choose the effective ways of solving both reproductive and creative tasks; quickly change the types and forms of intellectual activities without reducing their productivity (Mikhnenko, 2016).

English for Specific Purposes (ESP) belongs to humanities, and at the same time provides special subjects. Learners' needs and expectations are the basic principles for course designs in ESP (Richards, 2001). The core of ESP is its integration with special subjects in order to synthesise and acquire professional knowledge and to form significant personal qualities of future specialists. ESP, in this case, is a means of improving professional competence and personality development.

The purpose of the article is to study the formation of intellectual mobility of engineering students through the integration of foreign language education and professional training in an educational environment of a technical university. The following objectives are stated: 1) to analyse the necessity of intellectual mobility formation through integration of foreign language education and professional training; 2) to determine pedagogical conditions for the formation of intellectual mobility of engineering students; 3) to check the effectiveness of the implementation of pedagogical conditions for the formation of intellectual mobility of engineering students.

Methods

To solve the tasks of the research, the following set of methods was used: a) theoretical methods: analysis, interdisciplinary synthesis, comparison; classification and systematisation of theoretical data; logical generalisation (for making conclusions and recommendations for the formation of intellectual mobility in technical universities); b) empirical methods: diagnostic (questionnaires, interviews, psychological diagnostic techniques), observation; pedagogical experiment (ascertaining and formative experiments) to test the effectiveness of pedagogical conditions of the formation of intellectual mobility; c) methods of mathematical statistics (using Student's *t*-test) for processing and evaluating data validity of the results of the pedagogical experiment and determining the quantitative dependence between the phenomena under study.

The pedagogical experiment implied three stages. At the organisational stage, we specified conceptual apparatus of the research, developed the experimental programme and carried out the ascertaining experiment. The stage of realisation of pedagogical conditions was devoted to making the formative experiment and had two successive substages (motivational stage and activities stage) during teaching the discipline "English for Professional Communication" (ESP) in V-VII terms at tertiary level. During the generalisation stage, we processed the results of the experiment and determined the efficiency of the pedagogical conditions.

The formative experiment was conducted with 92 electrical engineering students from the Igor Sikorsky Kyiv Polytechnic Institute: 47 students were in the control group (CG), 45 students – in the experimental one (EG). The control group students were taught by means of traditional teaching methods, without application of the determined pedagogical conditions. The constant conditions for both groups were as follows: the number of students; locality; duration of the experiment; topics in accordance with syllabus; teaching by the same ESP teacher.

Theoretical research and practical experience helped us to determine pedagogical conditions for the formation of intellectual mobility of engineering students in a technical university: 1) the change in the function of a teacher when he /she becomes the moderator of intellectual activities of students, in which the latter become active converters of information (due to the use of interactive teaching methods as well as information and communication technologies (ICT)); 2) purposeful development of students' motivation to intellectual activity due to teacher's consideration of their individual psychological characteristics; 3) integration of the content of foreign language education and professional training, vocational orientation of foreign language learning with the use of distance learning courses, intellectual games and brainstorming tasks (Mikhnenko, 2016).

To test the effectiveness of pedagogical conditions through a pedagogical experiment, we distinguish four components in the structure of intellectual mobility, which coincide with the names of developed criteria, namely: motivational, cognitive, technological, social and personality (Mikhnenko, 2016). The motivational criterion is represented by such indicators as students' awareness of the significance of their own intellectual development; the presence of a deep interest in the intellectual activity. The indicators of the cognitive criterion are: students' knowledge of intellectual mobility and their own individual psychological traits; the level of thinking (cognitive flexibility, speed, depth, independence); the level of thinking operations and creativity in intellectual activities. The indicators of the technological criterion are: the level of instrumental competencies (ability to communicate in mother tongue and foreign languages, computer skills, information management skills); use of techniques and strategies for performing intellectual activity. To the social and personality criterion we included adaptively important personality traits, namely: businesslike efficiency, emotional stability, responsibility, activity; communication skills; tolerance, recognition of the view diversity; persistence in achieving goals.

In order to check the level of formation of these four components, during the experiment the following questionnaires and intelligence tests were used: 1) motivational component – "Incentives for learning" (revised by Azatyan, 2015), Cattell 16PF test; 2) cognitive component – cognitive flexibility test by Lachins, "Circles" by Vartega, intellectual lability test, Cattell 16PF test, "Brain-dominance questionnaire" (revised by Davies, 1994); 3) technological component – the English language tests in reading, writing, speaking, listening, translation skills and using ICTs while making projects; questionnaire "Autonomy of students" (Petrovskaya, 2010) to identify the strategies used by the students; 4) social and personality component – adaptability test by Rogers, responsibility test by Ostasheva, tolerance test, Cattell 16PF test, EIQ test (Hall, 1997), questionnaire "Autonomy of students" (Petrovskaya, 2010) to determine how persistent the students are in achieving the goals.

In accordance with the criteria and indicators, we identified three levels of intellectual mobility as a characteristic of a personality: reproductive – elementary manifestation of the indicators; varying – situational manifestation of the indicators; creative – when the student is oriented toward creativity, independent project execution and is able to quickly find, analyse and effectively apply information, quickly change the types and forms of intellectual activity without reducing its effectiveness.

Results

In order to realise the first pedagogical condition in an ESP class, we used pedagogical technologies based on the intensification of students' activities – interactive methods and information and communication technologies (ICT). We used business games, discussions, case-study method, projects and brainstorming.

While introducing various types of discussions (debates, talk-show), we confirmed that subject-subject interaction of a teacher and a student in ESP teaching results in the open, sincere sharing their own opinions. The students knew that not the ideas expressed would be assessed, but the use of the language, so, as a result, the discussions participants were active and impartial. The most successful discussions with the students of the experimental group were: "The War of Currents: AC and DC in modern life", "Engineering Mobility", "Renewables in Ukraine", etc.

The case-study method gives students the opportunity to read through the context of real-life problems, see the full complexity of those situations and apply their own analysis in deriving a solution (Spackman & Camacho, 2009). In case studies, every generated idea should be logically proven and well-grounded to bring about the solution to the problem. When using this method we chose the real life situation of engineers, for example, "Using Energy Efficiency Facilities in Power Supply Company", "Choosing Equipment", and "Apprentices at Work". Compared to case-studies, brainstorming is aimed only at generating ideas, at creating 'the bank of ideas' (even paradoxical) for further consideration and analysis (Tarnopolsky, 2012). The favourite brainstorming tasks for our future engineers became "Multiple uses of the thing" and "Objects that can make you crazy".

To make a project, the students had to fulfil four main tasks: 1) organise and plan the project, choose the means; 2) collect the material and create a working version of the project; 3) make a final text; 4) present the project results (usually in PowerPoint) and evaluate it (through both self- and peer-assessment). The themes of the projects were chosen independently by students' teams, but only in the field of their study. Project work cannot be realised today without using ICTs, which help to teach students the researching methods, methods for systematising and presenting information, to develop the presentation skills as well as different types of control and self-control.

The means of realisation of the second pedagogical condition were individual and group psychological diagnostic techniques, questionnaires, interviews with students, as well as teaching students the strategies and techniques of intellectual activities in accordance with their individual psychological characteristics. These

types of activities were organised both in an ESP class (esp., by using English versions where possible) and during tutorials. While interpreting the results of diagnostic techniques, students acquired some psychological knowledge, and as objects of this diagnostics they changed themselves and obtained reflection skills.

To realise the third pedagogical condition we developed the Moodle distance learning course entitled "English for Future Engineers" (Mikhnenko, 2014) and a set of intellectual games and brainstorming tasks aimed at creating the intellectual mobility while teaching students ESP.

The distance course "English for Future Engineers" consists of five modules and a final test. Each module includes listening, reading comprehension tasks, language in use part, glossary, writing business correspondence (CVs, job applications, etc.). The topics of professionally-oriented communication about the specifics of the engineer's work, recruitment strategies, motivation to perform work, professional development, as well as the implementation of safety rules in the workplace are given in the context of the activities of world-known energy companies. In addition, the course met the requirements of speed and unpredictability while performing the tasks.

Students' work on the course was carried out in two modes: a learning mode (when students could see the correct answers after the task had been completed) and a test mode. The forum and questionnaire allowed our students to share their impressions of the course, point to interesting and useful activities for them, and give recommendations to those who will perform the tasks of the course in the future. The students highly appreciated the possibility of self-correction in the learning mode and the implementation of an individual approach. According to their opinions, limitation of the number of attempts and allocated time for performance greatly contributed to both mobilisation of their intellectual resources and interest in learning. The students compared the performance of tasks on Moodle with the game, which is a fundamental difference from the traditional set of exercises in a foreign language textbook.

During the generalisation stage, we processed the results of the experiment and determined the efficiency of the pedagogical conditions by comparing the results of the experimental (EG) and control (KG) groups with the help of Student's *t*-test. The analysis of the results of the experiment made it possible to state that the indicators of the levels of intellectual mobility of engineering students increased significantly in the EG, while in the CG there was the slight positive dynamics (Table 1). The differences between the groups are significant and make up the value of $p \leq 0.05$.

Table 1

Levels of intellectual mobility of engineering students before and after the formative experiment, %

Components	Groups	Levels					
		Reproductive		Varying		Creative	
		Before	after	before	after	before	after
Motivational	EG	41,15	13,02	52,20	47,02	6,65	39,96
	CG	37,25	30,89	51,05	58,49	11,70	10,62
Cognitive	EG	24,13	10,02	58,41	45,94	17,46	44,04
	CG	21,24	16,73	59,93	57,75	18,83	25,52
Technological	EG	37,77	18,33	47,78	53,89	14,45	27,78
	CG	36,17	26,59	50,53	55,32	13,30	18,09
Social and personality	EG	14,32	11,11	64,95	63,22	20,73	25,67
	CG	11,35	11,40	69,95	69,48	18,70	19,12

As it is seen from Table 1, there is the most significant change in the indicators of the motivational component of the formation of intellectual mobility: the number of students in the EG with the reproductive level of this component decreased from 41.15% to 13.02% (in the CG - from 37.25% to 30.89%); the number of students with the creative level increased from 6.65% to 39.96% (in the CG – from 11.70% to 10.62%), and the number of students with a varying level became 47.02% in the EG, and 58.49% in the CG. The positive dynamics is also observed in the cognitive component (the growth at the creative level in the EG is 26.58%, and in the CG – 6.69%), technological (the growth is 13.33% and 4.79% respectively) as well as social-and-personality (4,94% in the EG and 0,42% in the CG, respectively) components of the formation of intellectual mobility of engineering students.

The results have confirmed our hypothesis that the formation of intellectual mobility of engineering students in an educational environment of a technical university can be effective by implementing the pedagogical conditions, the core of which is the integration of foreign language education and professional training.

Discussion

To meet the requirements of the XXI century, engineers must have a high level of intellectual, fundamental, special, and practical professional training, as well as be intellectuals and innovative thinkers.

It has been established that the implementation of the integrated approach (Vaintraub, 2009; Luzik, 2010, etc.) in the training of engineering specialists tends to be the main in the process of intellectualisation of professional training. To perform the research tasks, the integrative approach is dominant since it ensures the formation of intellectual mobility through a combination of the professional training and foreign language education.

The reason behind the choice of the discipline "Foreign Language for Professional Communication" (ESP) as a means of forming intellectual mobility is both its integrative content and the features of this discipline itself. It is found that the changes that occur in an individual's mind during foreign language learning are manifested both in cognitive acts and communication: the ability to use two (or more) languages in the process of communication as well as intellectual capabilities are developing; creativity, the ability in systematical perception of thoughts and actions, tolerance, and willingness to risk are increasing. Pravdina (2006) points out that the integration of general and ESP is a professional necessity: it promotes the development of systemic creative thinking as an important tool for the work of a specialist, develops professional abilities and skills, provides an additional tool for obtaining knowledge, expands access to information, and forms the culture of a specialist.

The analysis of pedagogical research proves that intellectualisation of professional training is possible if an educational environment of a technical university allows revealing and developing currently necessary personal qualities of future engineers. The characteristic features of such an environment (Mikhnenko, 2014) are: the organic integration of educational, scientific and innovative activities, communicativeness, information character of the environment which prompts students to intellectual activities with the active use of ICTs in the educational process, as well as the intellectual saturation of the educational environment which must be challenging, unpredictable and diverse.

In order to meet these requirements, teaching ICTs, esp. the resources of distance learning, e.g. on Moodle platform, can be developed and used successfully. At present, blended learning and mobile technologies (Berge & Muilenburg, 2013) are becoming more and more popular in teaching practice. Distance learning course allows differentiating the learning process, controlling the student's results, changing the time to perform tasks, increasing interest by using games (e.g. crossword puzzles) both in practice and test regimes.

In order to form intellectual mobility on the basis of the integration of foreign language education and professional training, the content block of general professional knowledge and the block of linguistic knowledge and skills in foreign language communication should be ensured, the educational material being given in accordance either in advanced, synchronous or retrospective way. Content should be a vehicle to drive language learning (Hadley, 2001). Text materials should be authentic, informative, thematically close to the content of special disciplines, and universal to be used in teaching students with different levels of language competence. It is essential for them to reflect contemporary developments in science and technology and to include motivational, conceptual, theoretical and general cultural knowledge.

As intellectual mobility implies the readiness for quick search, analysis and efficient application of information, the content of teaching materials should satisfy the requirements of speed and unpredictability when performing tasks. In addition, teaching materials should be clearly structured, and the use of charts, tables, tasks that require mobilising intellectual resources are essential. The tasks with different levels of complexity and adherence to the time limits as well as the introduction of competitive forms of training are effective, too.

It is important that ESP teaching materials give students the right and opportunity to choose the type of the activities according to their capabilities and needs. Furthermore, to provide individualisation and meet the needs of students, ESP teachers are advised to estimate the students' linguistic intelligence and help them to develop an awareness of their learning styles and preferences to choose the appropriate learning strategies (Zoghi, 2017).

Conclusions

The analysis of the quantitative and qualitative results of experimental work gives grounds to assert that the purpose of the research to study the formation of intellectual mobility of engineering students through the integration of foreign language education and professional training in an educational environment of a technical university has been achieved. We have proven the efficiency of the determined pedagogical conditions and developed some scientific and practical recommendations at administrative, methodological

and practical levels for teaching staff of technical universities regarding the formation of intellectual mobility of future engineers.

Prospective directions for scientific research to be proposed are as follows: the peculiarities of the formation of intellectual mobility of specialists in engineering specialties and the development of a system of teaching and methodological complexes on their basis to ensure this process in the educational environment of a modern technical university.

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