Exploring Computer Engineering and Information Technology Undergraduates' Views on Developing Their Innovative Thinking in English Classroom

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Abstract. **In our modern world, which is full of technological advancements, being able to think innovatively is essential for coping successfully with life and work challenges. For specialists who are going to work in the field of Computer Engineering and Information Technology innovative thinking is an ability that helps them adapt quickly to new challenges and opportunities and find non-standard solutions to various issues. In the study the researchers focused on finding out effective teaching and learning methods and techniques which can be used in the English language classroom for developing innovative thinking among Computer Engineering and Information Technology undergraduates. Considering the fact that the researchers are the English language teachers, to select the research sample they used a combination of a purposive sampling technique and a convenience sampling technique. To gather data on Computer Engineering and Information Technology undergraduates' views on developing their innovative thinking in the English Language classroom the researchers created a web-based questionnaire using Google Forms. The link to the questionnaire was distributed to the first- and second-year Computer Engineering and Information Technology students who study English as a second language at Kyiv National University of Technologies and Design. The results obtained enabled the researchers to identify teaching and learning methods and techniques effective for developing innovative thinking among Computer Engineering and Information Technology undergraduates.**

Keywords: Computer Engineering and Information Technology undergraduates, English classroom, innovative teaching and learning methods and techniques, innovative thinking.

I. INTRODUCTION

Life in our modern world, which is full of technological advancements in computer science and information technology, puts forward new requirements for the quality of the system of university training. To cope successfully with life and work challenges, university graduates should acquire core competencies which enable them both to navigate the current labour market conditions effectively and to navigate their careers confidently [1]. And one of these core competencies is the ability to think innovatively.

For professionals who are going to work in the field of computer engineering and information technology innovative thinking is an ability that helps them adapt quickly to new challenges and opportunities and find non-standard solutions to various issues. According to various classifications, innovative thinking is regarded as one of the most important job skills of the 21st century. Thus, for

instance, World Economic Forum [2] defines four categories of job skills of tomorrow which are of paramount importance for both present-day employees and employees who will enter the labour market in the future, namely, problem-solving, self-management, working with people and technology use and development. Such skills as analytical thinking and innovation; complex problem-solving; critical thinking and analysis; creativity, originality and initiative; reasoning, problem-solving and ideation represent the problem-solving category. Self-management category includes the following skills: active learning and learning strategies resilience, stress tolerance and flexibility. Working with people category contains leadership and social influence skills and technology use and development category consists of technology use, monitoring and control skills and technology design and programming skills.

The research conducted in 2021 by a group of Ukrainian scientists clearly demonstrates that analytical thinking and innovation as one of the job skills of tomorrow is praised rather high among Computer Engineering and Information Technologies undergraduates [3].

We fully agree with Ness, that "Innovation is the engine of scientific progress …" [4, p. 114] and can add that innovation is also the main driving force of advances in computer science and information technology. What we mean is that technological advancements in computer science and information technology are made possible due to both profound subject matter knowledge and innovative thinking of their inventors and developers. Since Ness believes that "great innovators are great observers" [5, p. 115], the scientist is convinced that innovative thinking is inextricable linked with attention which has to be developed during studies.

In this regard it is difficult to disagree with Dunlop, who considers innovative thinking as "the ability to come up with new ideas and novel approaches to problems" [6]. In Dunlop's point of view innovative thinking is connected with a person's ability to be flexible, to adapt to change, to solve problems creatively, to remain competitive in the marketplace.

Wang & Zhu [7] suggest that innovative thinking is not an inborn ability. It is the ability that can be developed during the studies and English as a college discipline is an effective medium for its development. The researchers state that to guide students' innovative thinking when teaching various texts, English teachers have to ask students multi-angled questions. Wang & Zhu explain that "as long as the teacher asks questions in the classroom timely and cleverly, students will perform a variety of mental trainings, and then students will be able to get the full improvement of innovative thinking" [8, p. 1843]. The researchers also claim that creative retelling and making creative speeches are effective teaching methods in developing students' innovative thinking.

A similar view concerning the didactic potential of English in developing college and university students' innovative thinking ability is shared by Zhang [9]. The researcher makes an assumption that the development of students' innovative thinking should be based on the idea of Wisdom education and should include the following activities, namely, inquiry-based activities, simulation-based learning activities, individualised learning activities, activities aimed at critical reading, writing and listening. Considering the fact that innovative thinking enables people to discover the world, the researcher states that it combines "perceptual skill, divergent thinking ability, and strong comprehension ability" [10, p. 136].

Believing that innovative thinking can be regarded as one of the main bridges between new and old knowledge, Cai defines innovative thinking as "the process of thinking activities that have novelty, uniqueness, and originality, that can reflect the essential attributes of things, and have internal and external organic connections, and can obtain new knowledge and new results [11, p. 218]. According to Cai [12], the structure of innovative thinking represents a trinity system which consists of logical thinking, critical thinking and creative thinking. The researcher is convinced that English reading teaching positively affects the formation of innovative thinking and therefore should be used in the English language classroom.

Literature review shows that present-day researchers consider English as an effective medium for promoting the enhancement of Computer Engineering and Information Technology undergraduates' soft skills or job skills of tomorrow which enable Computer Engineering and Information Technology undergraduates to be more adaptive and to successfully navigate various challenges and seize new opportunities [13], [14], [15]. To enhance soft skills development among Computer Engineering and Information Technologies undergraduates, Malykhin, Aristova & Melikova devised the soft skills development strategies that can be applied in the English language classroom [16]. The scientists proved the fact that if the learning content of English for Specific Purposes at universities meets the current requirements of the present-day globalized society, Computer Engineering and Information Technologies undergraduate students show more willingness to study English, on the one hand, and to acquire soft skills needed in their professional activities, on the other hand.

Thus, the research aim is to find out effective teaching and learning methods and techniques which can be used in the English language classroom for developing innovative thinking according to Computer Engineering and Information Technology undergraduates' views.

II. MATERIALS AND METHODS

Since the researchers are the English language teachers, they used a combination of a purposive sampling technique and a convenience sampling technique to select the research sample. The choice of the purposive sampling technique is explained by the researchers' interest in Computer Engineering and Information Technology undergraduate students' perspective on the stated problem and the choice of the convenience sampling technique is explained by the fact that the researchers teach English to Computer Engineering and Information Technology undergraduate students who study at Kyiv National University of Technologies and Design. To gather data on Computer Engineering and Information Technology undergraduates' views on developing their innovative thinking in the English Language classroom the researchers created a web-based questionnaire using Google Forms. The researchers distributed the link to the questionnaire to

the first- and second-year Computer Engineering and Information Technology students who studied English as a second language at Kyiv National University of Technologies and Design with a request to take part in the study. 173 first- and second- year students responded to the request and took part in the survey. It should be noted that all the respondents were assured of the anonymity of their responses.

The web-based questionnaire was aimed at finding out Computer Engineering and Information Technology undergraduates' views on the effective teaching methods and techniques which can be used in the English language classroom for developing their innovative thinking. The web-based questionnaire is composed of two parts. The first part of the questionnaire contains 3 questions and its main purpose is to gain insight into Computer Engineering and Information Technology undergraduates' views on their being able to think innovatively. The research questions are as follows:

1. Do you believe that you are innovative and can create innovative ideas?

2. Do you believe that innovative thinking is essential for your future professional life?

3. Can you list some skills which in your opinion form an integral part of innovative thinking?

The second part of the questionnaire contains two sets of items on a 5-Likert scale. The first set of items on a 5-Likert scale is targeted at finding out the frequency of use of the selected activities in the English language classroom aimed at developing Computer Engineering and Information Technology undergraduates' innovative thinking (1 – never, 2 – seldom, 3 – sometimes, 4 – often, 5 – always). Table 1 demonstrates the first set of items on a 5-Likert scale targeted at finding out the frequency of use of the selected activities in the English language classroom.

TABLE 1 THE FIRST SET OF ITEMS ON A 5-LIKERT SCALE

Activities	Variables				
	1 (Never)	2 (Seldom)	3 (Sometimes)	4 (Often)	5 (Always)
Note-taking mind mapping					
Drawing ambiguous pictures					
Incomplete pictures					
Expending and cutting down sentences					
Brainstorming					
Making up stories					
Chain story writing					
Reading comprehension mind mapping					
Writing storms					
Individual projects					
Group projects					
Finding associations					
Invention techniques: modifying and reversing					

Source: own study

The second set of items on a 5-Likert scale aims to find out Computer Engineering and Information Technology undergraduates' views on the most effective activities used in the English language classroom and intended for developing their innovative thinking (1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5 – strongly agree). Table 2 presents the second set of items on a 5-Likert scale aimed at finding out Computer Engineering and Information Technology undergraduates' views on the most effective activities used in the English language classroom.

TABLE 2 THE SECOND SET OF ITEMS ON A 5-LIKERT SCALE

Activities	Variables				
	1 (Strongly disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly agree)
Note-taking mind mapping					
Drawing ambiguous pictures					
Incomplete pictures					
Expending and cutting down sentences					
Brainstorming					
Making up stories					
Chain story writing					
Reading comprehension mind mapping					
Writing storms					
Individual projects					
Group projects					
Finding associations					
Invention techniques: modifying and reversing					

Source: own study

The data obtained were analysed using frequency and mean percentage to interpret respondents' responses.

III. RESULTS AND DISCUSSION

The first research question is "*Do you believe that you are innovative and can create innovative ideas?*". Replying to this question, 89 respondents (51.45%) gave an affirmative response. 34 respondents (19.65%) responded negatively and 50 respondents (28.90%) found it difficult to answer this question. Fig. 1 shows respondents' responses on question 1.

Taking into account the fact that innovative thinking is usually associated with the person's ability to brainstorm new and original ideas and identify new ways for solving non-standard problems, we strongly believe that the respondents who give a negative response and respondents who find it difficult to answer this question underestimate their innovative thinking ability although they have all the potential to innovate.
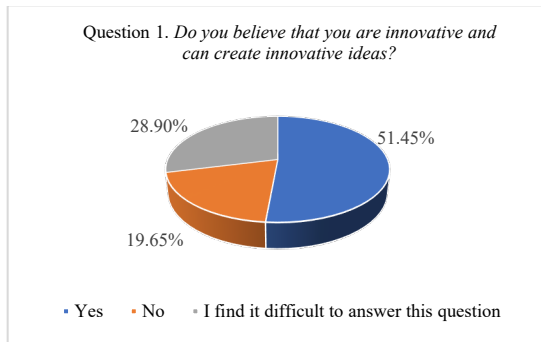
Fig. 1.   Respondents' responses concerning the question if they are innovative and can create innovative ideas.

The second question is aimed at finding out if respondents believe that innovative thinking is essential for their future professional life. The obtained results show that 104 respondents (60.12%) answered positively, 31 respondents (17.92%) responded negatively and 38 respondents (21.96%) found it difficult to answer this question. Respondents' responses on question 2 are given in Fig. 2.
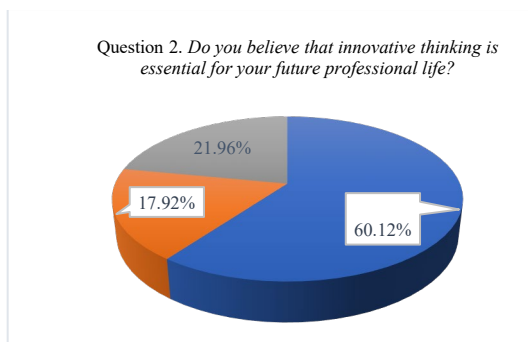

Fig. 2.   Respondents' responses on the question if innovative thinking is essential for their future professional life.

The main aim of the third question is to figure out what skills, in respondents' views, form an integral part of innovative thinking. The results obtained are presented in Table 3.

Thus, as shown by the results obtained, in respondents' views innovative thinking skills include creativity (88.44%), ability to analyse information (86.18%), ability to think critically (76.30%), ability to see the differences (62.48%), openness to new experience (93.06%), willingness to experiment (32.95%), ability to summarise information (83.27%), ability to group different ideas (41.62%), ability to evaluate information critically (73.41%), ability to find the way out of the situation (52.60%), adaptability to change (71.68%) and ability to be agile (44.51%). It should be noted that all the skills mentioned by respondents enable a person to create some new ideas, be innovative and, what is more important, not to stop there. Listing the skills which, in their opinion, are associated with innovative thinking the respondents focus on the fact that innovative thinking requires a practice which is difficult and time-consuming.

TABLE 3 RESPONDENTS' VIEWS ON SKILLS ASSOCIATED WITH INNOVATIVE THINKING

Innovative Thinking Skills	Number (N)	Percent (%)
Creativity (ability to generate new ideas)	153	88.44
Ability to analyse information (data)	149	86.18
Ability to think critically	132	76.30
Ability to see the differences	108	62.48
Openness to new experience	161	93.06
Willingness to experiment	57	32.95
Ability to find the way out of the situation	91	52.60
Adaptability to change	124	71.68
Ability to be agile	77	44.51
Ability to summarise information	144	83.27
Ability to evaluate information critically	127	73.41
Ability to group different ideas	72	41.62
Ability to keep doing something difficult in order to achieve a goal	101	58.38

Source: own study (N=173)

The third question is "*Do you believe that innovative thinking can be developed in the English language classroom*?" Replying to this question, 91 respondents (52.60%) gave a positive answer. According to 29 respondents (16.76%), innovative thinking cannot be developed in the English language classroom. 53 respondents (30.64%) find it difficult to answer this question. Fig. 3 demonstrates Computer Engineering and Information Technology undergraduates' views on the effectiveness of English as a discipline in developing their innovative thinking.
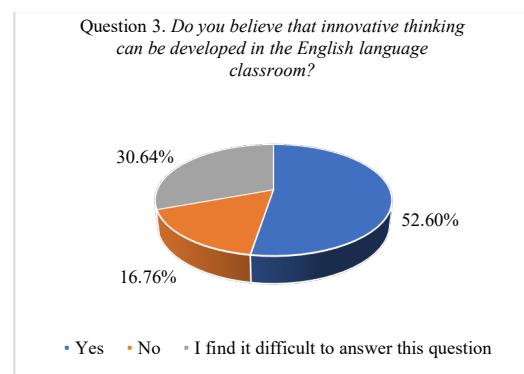

Fig. 3.   Respondents' responses on the question on effectiveness of English in developing their innovative thinking.

Then, respondents are asked to rate the frequency of use of the activities aimed at developing innovative thinking in the English language classroom according to a 5-Likert scale (1 – never, 2 – seldom, 3 – sometimes, 4 – often, 5 – always). The obtained results are shown in Table 4.

TABLE 4 RESPONDENTS' VIEWS ON FREQUENCY OF USE OF ACTIVITIES AIMED AT DEVELOPING INNOVATIVE THINKING

Activities	Variables					($\bar{x}$)
	1 (N)	*2 (N)*	*3 (N)*	*4 (N)*	*5 (N)*	
Note-taking mind mapping	0	0	16	72	85	4.39
Drawing ambiguous pictures	0	93	80	0	0	2.46
Incomplete pictures	87	64	22	0	0	1.62
Expending and cutting down sentences	0	0	87	59	27	3.65
Brainstorming	0	0	0	74	99	4.57
Making up stories	0	0	12	53	108	4.55
Chain story writing	0	0	12	53	108	4.55
Reading comprehension mind mapping	0	0	25	86	62	4.21
Writing storms	0	0	59	82	32	3.84
Individual projects	0	0	0	55	118	4.68
Group projects	0	0	74	62	37	3.78
Finding associations	0	0	81	64	28	3.69
Invention techniques: modifying and reversing	34	83	56	0	0	2.12

Source: own study (N=173)

The obtained results show that the most frequently used activities aimed at developing Computer Engineering and Information Technology undergraduates' innovative thinking include individual projects ($\bar{x}$=4.68), brainstorming ($\bar{x}$=4.57), making up stories ($\bar{x}$=4.55), chain story writing ($\bar{x}$=4.55), reading comprehension mind mapping ($\bar{x}$=4.21). As the results show, in their classrooms English language teachers also use such activities as finding associations ($\bar{x}$=3.69), writing storms ($\bar{x}$=3.84), cutting down and expending sentences ($\bar{x}$=3.65) and group projects ($\bar{x}$=3.78) to develop Computer Engineering and Information Technology undergraduates' innovative thinking. The analysis of the results enables us to conclude that development of educational materials aimed at implementing these activities in the English language classroom is time-consuming and although English teachers use them in their classrooms, it does not happen very often. It is associated with the fact that during the first and second years of university education (English as a second language) and the following third and fourth years (English for Specific Purposes), the duration of face-to-face interaction of English teachers and students is not sufficient for paying special attention to the purposeful, comprehensive and systematic development of Computer Engineering and Information Technology undergraduates' skills of the 21st century including innovative thinking. Unfortunately, such invention techniques as modifying and reversing ($\bar{x}$=2.12), drawing ambiguous pictures ($\bar{x}$=2.46) and incomplete pictures ($\bar{x}$=1.62) are among those which are rarely used in the English language classroom, although their purposeful, comprehensive and systematic use can contribute greatly to the development of innovative thinking in general and each individual innovative thinking skill which constitutes innovative thinking in particular. All these activities, in our opinion, can be grouped in several categories which represent teaching and learning methods and techniques aimed at developing Computer Engineering and Information Technology undergraduates' innovative thinking in the English language classroom. Table 5

demonstrates both categories of teaching and learning methods and techniques and activities used for developing Computer Engineering and Information Technology undergraduates' innovative thinking in the English language classroom.

TABLE 5 TEACHING AND LEARNING METHODS AND TECHNIQUES AIMED AT DEVELOPING INNOVATIVE THINKING

Categories	Activities
Story-based teaching and learning methods and techniques	- *making up stories* - *expending sentences* - *chain story writing* - *cutting down sentences* - *writing storms*
Mind mapping teaching and learning methods and techniques	- *note-taking mind mapping* - *brainstorming* - *reading comprehension mind mapping*
Association-based teaching and learning techniques	- *finding associations* - *drawing ambiguous pictures* - *incomplete pictures* - *invention techniques: modifying and reversing*
Project-based teaching and learning techniques	- *individual projects* - *group projects*

Source: own study

The second set of items on a 5-Likert scale aims to find out if Computer Engineering and Information Technology undergraduates agree that the following activities are the most effective for developing their innovative thinking in the English language classroom. To describe the variables, the researchers use means ($\bar{x}$). Computer Engineering and Information Technology undergraduates' perspectives on effectiveness of the listed activities are measured from 'strongly disagree' to 'strongly agree' based on the 5-Likert scale intervals presented in Table 6.

TABLE 6 INTERVAL LEVEL OF 5-LIKERT SCALE

Mean Interval	Perspective
1.00–1.80	*Strongly disagree*
1.81–2.60	*Disagree*
2.61–3.40	*Neutral*
3.41–4.20	*Agree*
4.21–5.00	*Strongly agree*

Table 7 demonstrates the obtained results concerning respondents' views on effectiveness of activities aimed at developing innovative thinking skills in the English language classroom.

The obtained results clearly demonstrate that according to respondents' views brainstorming ($\bar{x}$=4.61), reading comprehension mind mapping ($\bar{x}$=4.55), writing storms ($\bar{x}$=4.51), making up stories ($\bar{x}$=4.36), chain story writing ($\bar{x}$=4.36), invention techniques: modifying and reversing ($\bar{x}$=4.18), finding associations ($\bar{x}$=4.17), note-taking mind mapping ($\bar{x}$=4.45), individual ($\bar{x}$=4.53) and group projects ($\bar{x}$=4.37) are among the most effective activities aimed at developing innovative thinking in the English language classroom.

TABLE 7 RESPONDENTS' VIEWS ON EFFECTIVENESS OF ACTIVITIES AIMED AT DEVELOPING INNOVATIVE THINKING IN ENGLISH CLASSROOM

Activities	Variables					($\bar{x}$)
	1 (N)	*2 (N)*	*3 (N)*	*4 (N)*	*5 (N)*	
Note-taking mind mapping	0	0	10	76	87	4.45
Drawing ambiguous pictures	0	3	52	83	35	3.87
Incomplete pictures	0	2	54	79	38	3.88
Expending and cutting down sentences	0	29	87	40	17	3.09
Brainstorming	0	0	0	67	106	4.61
Making up stories	0	0	29	53	91	4.36
Chain story writing	0	0	27	56	90	4.36
Reading comprehension mind mapping	0	0	7	64	102	4.55
Writing storms	0	0	0	85	88	4.51
Individual projects	0	0	5	72	96	4.53
Group projects	0	0	17	75	81	4.37
Finding associations	0	12	22	63	76	4.17
Invention techniques: modifying and reversing	0	0	31	80	62	4.18

Source: own study (N=173)

IV. CONCLUSIONS

The research was targeted at finding out effective teaching methods and techniques which could be used in the English language classroom for developing innovative thinking among Computer Engineering and Information Technology undergraduates. The obtained results enable us to state that the majority respondents (51.45%) believe that they are innovative and are able to create new ideas. The majority of respondents (60.12%) are convinced that innovative thinking is essential for their future professional life. According to respondents, innovative thinking is associated with the following skills, namely: creativity (88.44%), ability to analyse information (86.18%), ability to think critically (76.30%), ability to see the differences (62.48%), openness to new experience (93.06%), willingness to experiment (32.95%), ability to find the way out of the situation (52.60%), adaptability to change (71.68%) and ability to be agile (44.51%). It should be also noted that 91 respondents (52.60%) are confident that innovative thinking can be developed in the English language classroom. The present research enabled its authors to identify effective teaching methods and techniques which can be used in the English language classroom with the aim to develop Computer Engineering and Information Technology undergraduates' innovative thinking. Among these techniques, we single out story-based teaching and learning methods and techniques (making up stories, chain story writing and writing storms), mind mapping teaching and learning methods and techniques (note-taking mind mapping, brainstorming, reading comprehension mind mapping), association-based teaching and learning techniques (finding associations, drawing ambiguous pictures, incomplete pictures, invention techniques: modifying and reversing etc.), project-based teaching and learning techniques (individual and group projects).

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