

## Fostering Engineering Students' Competences Development Through Lexical Aspect Acquisition Model

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**Abstract**—This study aims to investigate the effect of enhanced lexical aspect acquisition model on engineering students' competences development, namely such 21st century skills as communication (written or oral), self-organization, systematic and critical thinking, project development and implementation, team work, application of fundamental knowledge, work with information. The researchers have developed a novel approach to fostering lexical aspect acquisition through multistage model. The participants of the research were first-year engineering students of the mineral specializations in Saint-Petersburg Mining University. Suggested model-based learning process and conventional-based teaching were used in experimental and control groups accordingly during the spring term 2022. The SPSS software was used to interpret the obtained data. The statistical analysis was carried out with the output of Cronbach's Alpha reliability test and Pearson correlation test with identification of p-value. The findings showed a significant difference between the level of lexical acquisition in the control and experimental groups proving reliability and validity of the current research.

**Keywords**—communication, competence-based approach, technical education, vocabulary mastery, writing assignment

### 1 Introduction

Engineering education is at its strive and it needs modern and sophisticated methods to keep in pace with the ever-changing labour market demand. Professional requirements in engineering sphere expand through continuously involving new functions and creating new engineering professions in various industries [1]. From the global economics point of view, the mineral resource complex is one of the crucial aspects of sustainable development of the country [2]. Modern mining education is focused on the world-scale training, i.e. graduates are ready for working worldwide [3], which implies profound communication skills mastery of the foreign language. It is obvious that highly qualified specialists are fundamental for the sustainable economic development [4]. For achieving the main goals of engineering education it is necessary to have an in-depth knowledge of the search for and implementation of the advanced technologies [5].

According to the Federal State Education Standard of the Russian Federation future engineering specialists are to acquire general and professional competences, majority of which can be mastered in the course of second language learning: communication (written or oral), self-organization, systematic and critical thinking, project development and implementation, team work, application of fundamental knowledge, work with information. As Saint-Petersburg Mining University teaches would-be engineering specialists the authors are presumed to analyze professional goals in programs [6], to develop students' competences for adapting or relating expertise needed for future job with the graduates' competence assessment [7]. Engineering students should incorporate basic knowledge of many disciplines, not just mathematics and physics [8]. Among others, foreign language proficiency allows for greater career achievements [9]. Hence, the aforesaid competences are crucial for graduates' being able to adapt to constantly evolving new challenges and to meet requirements of potential employers.

The key importance of competence-based approach in engineering students teaching has been widely recognized by numerous researchers [10, 11, 12] who highlight a pressing need for general competences mastery such as communication skills, ability to cooperate, open-mindedness, willingness to make contact, empathy, shared responsibility, ability to make decisions, solidarity, etc. Within the framework of competence-based approach, the content of the engineering education has to be constantly modernized [13].

In Saint-Petersburg Mining University there are continuous efforts to enhance students' competence through well-designed and motivating assignments [14]. In their strive to enhance the quality of engineering education, lecturers of Mining University basically introduce experimental technologies and novel methods, for instance the use of modern augmented reality (AR) technologies [15]. While teaching would-be engineers it is necessary to apply advanced learning technologies which develop and improve all the aspects of foreign language competence for professional interaction [16]. Based on the aforementioned competences and various assignments, it can be concluded that there is a close link between the competence acquiring and different teaching strategies implementation [17, 18, 19, 20, 21].

Science and technology nowadays are developing quickly. The results of the researchers' surveys are published in the international journals and books that are laid open to public inspection [22, 23, 24]. Hence it is important for an engineer, who is going to evolve in scientific area and introduce innovations, to be able to express his or her ideas and research results in written form [25, 26, 27]. As a rule, it is the English language that is used by most international scientists and researchers to share their results with the public [28, 29]. Therefore, it is of vital importance to teach technical university students (who are not prone to humanitarian disciplines) to articulate their thoughts in qualitative written English [30, 31].

The skill of writing is one of the four traditionally educated skills of a foreign language mastering, along with reading, listening and speaking [32, 33, 34, 35]. The aspect of reading, especially foreign technical resources, acts is essential for the engineers to get relevant technical practical and theoretical knowledge in their profession [36]. The speaking aspect is responsible for producing both linguistically correct and utterances that are pragmatically appropriate [37]. As to the listening aspect, this ability gives higher education students an excellent opportunity to enhance their general proficiency

in English [38]. Writing relies on lexical and grammatical knowledge of the person, his or her ability to clothe ideas in words. Many people experience difficulties in this or that aspect of writing [39, 27, 40]. Writing is not engineering students' favorite activity [27] and this aspect poses challenges and problems for engineering students learning English as a second language around the world [41]. The researchers mention the most common difficulties in writing essays, namely: insufficient language proficiency; complicated and effortful tasks; incomplete knowledge of the topic of the writing assignment. Students need to stimulate numerous learning elements, such as second language proficiency, schemata knowledge and writing strategies [33]. Observing some troubles of their students while writing essays, the authors of this paper decided to introduce a lexical aspect acquisition model aimed at enhancing students' writing skills and focusing mainly on the lexical resource of the students.

In the process of their education, the students of the engineering specialties are to obtain not only the so called hard skills, i.e. professional knowledge, but also soft skills – a number of general skills and knowledge [42, 43, 44]. In [45] a roadmap to the development of seven key competences skills through seven teaching and learning strategies has been proposed. It should be mentioned that the engineers in technoscience, geoscience in particular, need to promote efficient thinking ability and self-control, soft skills, including communication and cooperation skills, problem-solving, conflict resolution, etc. [46] Furthermore, to gain proficiency, a specialist must also possess certain personal characteristics that would allow him or her to remain competitive, as well as develop general competences [47]. Using the terminology of the Russian educational system, soft skills can be called general competences, while hard skills refer to professional competences. Gaining general competences is an integral part of technical engineering education that forms a professional engineer's ability to compete in the labour market, in particular having a good command of English which is pivotal for future engineers of the raw materials industry [48], if they want to be competitive in the global labour market. English proficiency is an implicit advantage for young engineers. Highly qualified engineering specialists with proficient knowledge of foreign languages are in demand in a globalised world with knowledge-based economies [49].

So, it is the competence of writing communication in the foreign language, particularly vocabulary mastering, that is scrutinized in this paper.

The research questions (RQ1 for Research Question 1 and RQ2 for Research Question 2) put forward by the authors are the following:

RQ1: Does the multistage lexical aspect acquisition model prove to be effective in terms of students' academic performance in writing assignments?

RQ2: Does the general and professional competences acquiring through the multistage lexical aspect acquisition model prove to be effective?

## **2 Methods**

To address the research questions the authors put forward two hypotheses.

(1)  $H_0$ : Total Score and Lexical Aspect Score for the writing assignment in Experimental Group does not significantly differ from Total Score and Lexical Aspect Score for the writing assignment in Control Group.

$H_A$ : Total Score and Lexical Aspect Score for the writing assignment in Experimental Group significantly differs from Total Score and Lexical Aspect Score for the writing assignment in Control Group.

The second hypothesis deals with engineering students’ competences acquisition (C1 for Competence 1, C2 for Competence 2, up to C7 likewise).

List of Competences:

- C1 – Communication
- C2 – Self-organization
- C3 – Systematic and Critical Thinking
- C4 – Project Development and Implementation
- C5 – Teamwork and Leadership
- C6 – Using the Fundamental Knowledge
- C7 – Working with Information

(2)  $H_0$ : Competences C1–C7 acquisition in the experimental group does not significantly differ from competences C1–C7 acquisition in the control group.

$H_A$ : Competences C1–C7 acquisition in the experimental group significantly differs from competences C1–C7 acquisition in the control group.

## **2.1 Model of the enhanced lexical aspect acquisition**

The purpose of the lexical aspect acquisition model devised by the authors is a multifaceted work, both individual and group work, at home and in the classroom, aimed at the sustainable mastery of a number of competences. The model implementation was conducted during four months. The experimental group in which the model was introduced numbered 100 students (N=100). The control group which was taught without involving the model and studied all the topics in a conventional way numbered 97 students (N=97).

First-year engineering students at Saint-Petersburg Mining University at the beginning of academic year conduct placement tests which determine their level of English. The control and experimental groups included approximately even number of students with B1 (Intermediate), B2 (Upper-Intermediate), C1 (Advanced) level according to the Common European Framework of Reference (hereinafter referred to as CEFR scale).

In Saint-Petersburg Mining University, the educational programme of the foreign language course is devised according to Federal State Educational Standard and implies mastering in a number of grammar topics and a list of general lexical topics. Lexical topics include, for instance: “The usage of the foreign language”, “Mass Media”, “Environmental issues”, “Global problems of humanity”, etc. In order to improve the students’ acquisition of the lexical topics, the authors have devised the following model (see Table 1).

**Table 1.** Model of the enhanced lexical aspect acquisition distributed in stages

	Stage Zero	Stage One	Stage Two	Stage Three
Stages	a) Introducing the purpose and procedure; getting familiar with lexical topics.	c) Students’ individual work: selection of texts according to allocated topic, reading and translation.	d) Individual work: creating illustrated glossary to allocated topic in any format possible to be presented to the class. e) Group work: interactive presentation of glossaries to the class.	f) Preparation and fulfillment of written assignment to the lexical topics studied during stages one and two. g) Feedback from the educator. Feedback from the students.
	b) Distribution of topics between the students within each group.			
Competence*	1. Communication (written or oral)			
	2. Self-organization			
	3. Systematic and critical thinking			
	4. Project Development and Implementation			
	5. Team work			
	6. Application of fundamental knowledge			
	7. Work with information			

Note: \*Green colouring shows that the stage is embraced by the competence in the line.

The first stage of the suggested lexical aspect acquisition model is the students’ individual reading of texts on the topics envisaged by the educational program, dictionary work and text analysis, which corresponds to some items of the “Communication” (C1). In addition, this stage of work contributes to the formation of competence “Self-organization” (C2), as during the work students are required to effectively and competently distribute their time, search for necessary information, thus updating their socio-cultural and professional knowledge. Since the students select the sources of texts for individual reading on their own, it contributes to the mastery of the competence “Systematic and Critical Thinking” (C3), which is the ability to search and process information sources, including foreign ones.

The second stage of the project is the work with vocabulary on each of the topics. At this stage, students select the foreign vocabulary and terms needed to discuss each topic. Each prepares a presentation on the selected vocabulary. The presentation includes the words, their brief explanation and a visual illustration. In the class, each student presents their results in the form of ppt (or other formats) presentation and uses interactive format: demonstrates the prepared vocabulary to the audience, discusses its meaning and stipulates what should be written down. The audience during the class makes a glossary for each topic, writing down the word, guessing the translation from the speaker’s illustration and explanation. This phase of the model implementation

is designed to build both general and professional competences. First, students are engaged in collecting, organizing, and processing information in order to present the most relevant glossary for general use (C3). Secondly, the students are engaged in the project the aim of which is to enrich the vocabulary of the whole group; and each student is assigned their own topic to form a common knowledge bank for groupmates – “Project Development and Implementation” (C4). This is followed by the group work on vocabulary acquisition and boosting – “Teamwork and Leadership” (C5).

At the third stage students prepare for a written assignment – essay writing.

Each student from both control and experimental groups was given an answer sheet A4 format where an essay topic and assessment criteria were indicated. The participants were provided with the same writing essay conditions. There was set a time-limit of 40 minutes for accomplishing the given assignment. Furthermore, it needs to be said that the students were not allowed to use any supplementary materials while writing essays. At the beginning of the lesson the authors explained the required essay structure to engineering students, discussed what linking words, coherence and cohesion means, grammar range should be included in the essay. The key issue was confined to a holistic approach of lexical aspect acquisition model implementation in the experimental group.

It should also be noted that the above mentioned skills and competences contribute to the formation of not only general competences, but also professional competences, which are formulated individually for each specialty in each university, but it is possible to point out competences related to many professions of engineering field – “Using the Fundamental Knowledge” (C6), “Working with Information” (C7).

The writing assignment in the format of essay is the tool of progress check. The results of the essay are assessed on the adapted scale, which reflects the student’s ability to express their ideas on the topic in the written foreign language, analyze the problem, draw reasonable conclusions, and advance arguments for their point of view. In addition, the essay shows to what extent a student masters grammar and vocabulary in a foreign language in the form of written speech. The result of the essay, especially the lexical aspect of the essay, shows the effectiveness of the described methodology.

The researchers exert a widely-acknowledged system of writing skills assessment criteria based on IELTS, namely four aspects of Band Descriptors: “Task response”, “Coherence and Cohesion”, “Lexical resource”, “Grammatical range and accuracy”. The assessment scale was elaborated by the authors complying with educational programmes of Saint-Petersburg Mining University in the course of “Foreign language”. The assessment was conducted through the 5-point scale in each aspect with the total of 20 points.

Since the focus of the experiment is on the vocabulary acquisition, the researchers scrutinized this aspect of the writing assignment and devised an extended scale of five lexical aspects: 1) Proper usage of vocabulary (adequate choice of the words with proper meaning, problem of polysemy/multiple meanings, collocations and set expressions); 2) spelling; 3) sophisticated language (vocabulary level complies with their CEFR level – B1, B2, C1); 4) Synonyms (diversity, no tautology); 5) word formation (usage of suffixes, usage of prefixes, word building). For each aspect, a student could get 2 points if the student’s lexical aspect is presented in a perfect manner. 1 point is given in case the student has minor mistakes in the aspect. A student gets 0 points if he or she made more than three mistakes in the lexical aspect.

## 2.2 Questionnaire

In order to determine how well the students acquired the competences, apart from the results of essay writing, the authors also relied on questionnaires conducted among the experimental and control groups.

One of the most effective and frequently used methods of collecting material in pedagogical research is a questionnaire [50, 51, 52]. By means of questions specially designed for the questionnaire the necessary data are collected and subsequently analyzed.

In this study, the questionnaire contained the questions that were formulated so that it would be possible to conduct statistical analysis of representativeness and objectivity of the results. The Likert scale was chosen as the response system.

The questionnaire is aimed to assess the degree of general and professional competences formation with students who participated in the experiment and those who were in the control groups. In the questionnaire every question is marked with the number of competence described above.

## 3 Results and discussion

First, let us scrutinize the results of our research with regards to Academic performance of the students from experimental and control groups.

Hypothesis 1

Are Total Score and Lexical Aspect Score for the writing assignment in Experimental Group better than those in Control Group?

$H_0$ : Total Score and Lexical Aspect Score for the writing assignment in Experimental Group does not significantly differ from Total Score and Lexical Aspect Score for the writing assignment in Control Group.

$H_A$ : Total Score and Lexical Aspect Score for the writing assignment in Experimental Group significantly differs from Total Score and Lexical Aspect Score for the writing assignment in Control Group.

The collected data were processed manually and typed into the SPSS software for Windows (64-bit version) within one month, whereupon the computational opportunities of the software were used, namely the correlation test (with Pearson correlation and research significance output) as well as the reliability test (with Cronbach’s Alpha output).

**Table 2.** Correlation between the writing assignment score (and lexical aspect score in particular) and the students’ affiliation to the experimental or control group

		Total Score	Lexical Aspect Score
Experimental or Control group	Pearson Correlation	-.530**	-.682**
	Sign. (2-tailed)	.000	.000
	N	197	197

Note: \*\*Correlation is significant at the 0.01 level (2-tailed).

Table 2 shows the results of the statistical analysis of the correlation between the essay score, and lexical aspect score in particular, on the one side and the students’ affiliation to the experimental or control group on the other side. Negative correlation proves that the total score for writing assignment and its lexical aspect in particular in group 1 (experimental) is higher than in group 2 (control). Since the p-value of this correlation amounts to 0.000 and hence the correlation is significant, it can be concluded that experimental group performance is much better than the one in the control group and the implementation of the lexical aspect acquisition model proved to be effective.

**Table 3.** Reliability statistics of the Total Score and Lexical Aspect Score for the writing assignment

Construct	Cronbach’s Alpha	N
Score	.826	2

Using the SPSS software, the authors have checked the reliability and consistency of the writing assignment results. In terms of the construct of total scores (for the whole task and for the lexical aspect), Cronbach’s Alpha value of this data amounts to 0.826, which is greater than 0.70 (see Table 3).

In the view of the abovementioned statistical results the alternative hypothesis is accepted – the score performance of the students who studied through lexical aspect acquisition model significantly differs from the score of students who studied in a conventional way.

Hypothesis 2

Are the competences C1–C7 acquired better by the experimental group where the lexical acquisition model was implemented than in the control group which studied in a conventional way?

$H_0$ : Competences C1–C7 acquisition in the experimental group does not significantly differ from competences C1–C7 acquisition in the control group.

$H_A$ : Competences C1–C7 acquisition in the experimental group significantly differs from competences C1–C7 acquisition in the control group.

The questionnaire was conducted after the course of English. The students of both experimental and control groups participated in it. The questionnaire is aimed to determine to what extent the competences have formed. The questions are formulated in a form of statements (S1 for statement 1, S2 for statement 2, and likewise up to S12 for statement 12) so that positive answers show the respondents’ higher level of competences acquisition, while negative answers indicate that the competence implied by the statement is not vividly formed. For example, the questionnaire included the following items: statements “I can easily express my opinion on some problematic issue in the English language, such as pollution problem, advancements of technological development, etc” and “My vocabulary is sufficient enough to express my ideas and thoughts in written and oral communication in English” show the level of Communication competence (C1) formation. Some statements entail several competences at once, for example: statement “During my work at English classes, I managed to use Information and Communications technologies (ICT) effectively and to benefit” encodes competences of Using the Fundamental Knowledge (C6) and Working with Information (C7).



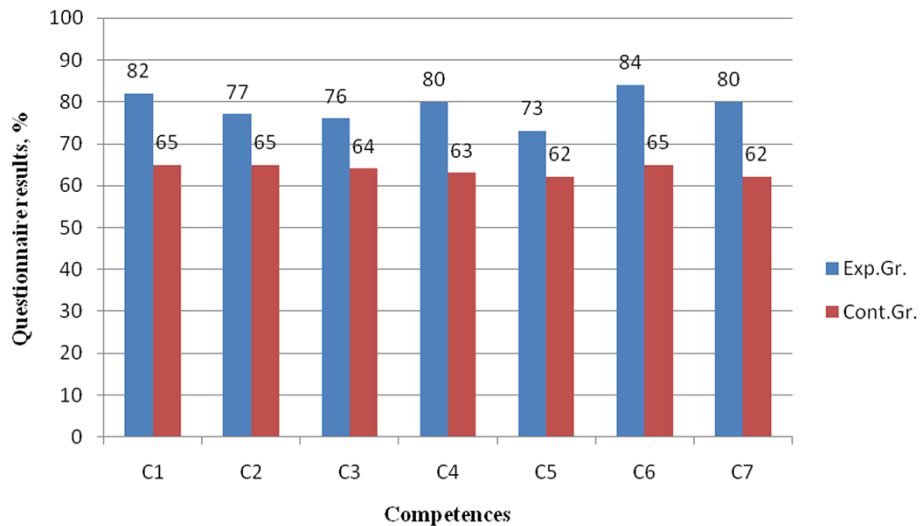


Fig. 1. Results of the questionnaire showing the competence acquisition level

The graph in Figure 1 shows the percentage of answers “Totally agree” and “Rather agree” in each group. The authors have gathered the scope of statements for each of seven competences separately and calculated only positive answers in experimental and in control groups and presented these results in the graph as opposed to the percentage of neutral and negative answers (not presented in the graph) such as answers “Undecided”, “Rather disagree”, “Totally disagree”, as neutral and negative responses demonstrate weak acquisition of competences.

It should be noted that in general all students showed appreciable results in terms of competences acquisition – the least percentage of positive answers to the competence defining statements is 62% in the control group, which is a good result and proves that in general the competences are acquired successfully by both groups. Nevertheless, it can be seen that the experimental group showed better results. Thus, students in the experimental group have developed the following competences significantly better than those in the control group: C1, C4, C6, C7, i.e. the number of positive answers differs by 17–19%. The following competences acquisition is presented better in the experimental group by 11–12% difference: C2, C3, C5.

Table 4. Correlation between the questionnaire answers distribution and the affiliation to control or experimental group

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Pearson Correlation	.249**	.222**	.242**	.174*	.187**	.238**	.148*	.238**	.199**	.202**	.224**	.227**
Sig. (2-tailed)	.000	.002	.001	.015	.009	.001	.038	.001	.005	.004	.002	.001
N	197	197	197	197	197	197	197	197	197	197	197	197

Notes: \*\* Correlation is significant at the 0.01 level (2-tailed). \* Correlation is significant at the 0.05 level (2-tailed).

Table 4 represents the correlation between the questionnaire answers distribution and the respondents’ affiliation to control or experimental group. There were twelve statements. The scale of answers entails the range from “1” (Totally agree) to “5” (Totally disagree), the positive correlation shown in the table proves that moving from the experimental group results to the control group results the answers tend to increase, i.e. be mostly “3”, “4” and “5” – “Undecided”, “Rather disagree”, “Totally disagree”. Hence, the experimental group results are mostly positive – “1” (Totally agree) and “2” (Rather agree). The p-value of the statistical analysis is within the range of 0.000 to 0.038 which shows that correlation is significant.

**Table 5.** Reliability statistics of the questionnaire answers distribution

Construct	Cronbach’s Alpha	N
Questionnaire statements	.946	12

Furthermore, checking the internal consistency of the competence statements responses via SPSS software has given the following Cronbach’s Alpha value for 12 items (statements) – 0.946, which is greater than 0.70 so the results are reliable (see Table 5).

Hence it can be concluded that students in the experimental group formed more sustainable competences than students in the control group and the null hypothesis can be rejected.

The interpretation of the questionnaire results and statistical analysis show that implementation of the devised by the authors lexical aspect acquisition model proved to be effective and enhances the process of obtaining a number of competences.

Drawing upon the competence-based approach the current study was an attempt to investigate the effect of lexical aspect acquisition model on general and professional competences mastering. In line with the findings of other studies scrutinizing competence development among higher educational students [53, 54, 55, 56] the results of the present research also indicated that various innovative lexis learning tools were more effective than conventional-based education process.

## 4 Conclusion

1. The results of the lexical aspect acquisition level proved to be different in proposed model-based learning process and conventional-based teaching format. The research results validated better academic performance during writing assignment accomplishment with the students who expanded their vocabulary bank with the help of multistage model application. The p-value of correlation between the writing assignment score (and lexical aspect score in particular) and the students’ affiliation to the experimental or control group amounts to 0.000 and hence the correlation is significant, it can be concluded that experimental group performance is much better than the one in the control group and the implementation of the lexical aspect acquisition model proved to be effective.
2. The multistage model was highly approved by the students from the experimental group. General competences, together with professional ones, proved to be obtained

much better by the engineering students whose English course included the devised lexical aspect acquisition model. The competences were mastered in both groups; however, the students in the experimental group have developed the competences communication, project development and implementation, using the fundamental knowledge, working with information significantly better than those in the control group, i.e. the number of positive answers differs by 17–19%. The competences self-organization, systematic and critical thinking, teamwork and leadership acquisition is presented better in the experimental group by 11–12% difference.

3. Implications. Having established the effectiveness of the multistage lexical acquisition model during the English course for the engineering students, the authors intend to continue their work on the model implementation. In the future study, it is reasonable to scrutinize each of the lexical aspects of the model, namely: proper usage of vocabulary (adequate choice of the words with proper meaning, problem of polysemy/multiple meanings, collocations and set expressions); spelling; sophisticated language (vocabulary level complies with their CEFR level – B1, B2, C1); Synonyms (diversity, no tautology); word formation (usage of suffixes, usage of prefixes, word building).
4. In this study, we also recognized some limitations. Selection and numbering of the competences were made by the authors on the basis of FSES (Federal State Educational Standards) and Educational Programmes of Saint-Petersburg Mining University. Besides, the study was conducted within one spring term 2022, so there is a need for further work on the issue within extended runtime.

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