THE EFFECT OF USING E-LEARNING TOOLS BASED ON VISUALIZATION IN TEACHING AND LEARNING LATIN

O EFEITO DE UTILIZAR FERRAMENTAS DE E-LEARNING BASEADAS NA VISUALIZAÇÃO NO ENSINO E APRENDIZAGEM DE LATIM

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Olena Balalaieva *olena.balalaeva@gmail.com*
Ph.D. in Pedagogy from the Institute of Information Technologies and Learning Tools of National Academy of Educational Sciences of Ukraine (Kyiv/Ukraine). Associate Professor on Department of Journalism and Linguistic Communication of National University of Life and Environmental Sciences of Ukraine (Kyiv/Ukraine).

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ABSTRACT

The article deals with the problem of using visualization in teaching and learning Latin. Both positive and negative implementation aspects of a classic didactic principle of visualization are analyzed in terms of e-learning. The experimental research aimed to carry out the system of pedagogical impact by means of e-learning tools based on visualization and evaluate the effect of using such tools on teaching and learning Latin. The ways to minimize didactic risks that may result from inappropriate (from psychological and educational points of view) use of visual aids in e-learning tools are outlined. The necessity to keep up with the demand for reasonable visualization sufficiency is shown. The pedagogical experiment has proved the advantage using of e-learning tools based on visualization in learning Latin by following criteria: motivation (indicators: focus and level of academic motivation), cognition (indicators: quality and amount of knowledge, academic performance), activity (indicators: mastering practical skills, speed of execution of training tasks). The results of the pedagogical experiment (including the comparison of the results of the experimental and control groups) give the grounds to state that training veterinary students with using e-learning tools based on visualization is more effective than the traditional one.

Keywords: Visualization. E-learning tools. Professional training. Latin.

RESUMO

O artigo trata do problema de usar a visualização no ensino e aprendizagem de latim. Aspectos de implementação positivos e negativos de um princípio didático clássico de visualização são analisados em termos de e-learning. A pesquisa experimental teve como objetivo realizar o sistema de impacto pedagógico por meio de ferramentas de e-learning baseadas na visualização e avaliar o efeito do uso de tais ferramentas no ensino e aprendizagem do latim. São descritas as maneiras de minimizar os riscos didáticos que podem resultar do uso inadequado (do ponto de vista psicológico e educacional) de recursos visuais nas ferramentas de e-learning. A necessidade de acompanhar a demanda por suficiência razoável de visualização é mostrada. O experimento pedagógico demonstrou a vantagem do uso de ferramentas de e-learning baseadas na visualização no aprendizado de latim, mediante os seguintes critérios: motivação (indicadores: foco e nível de motivação acadêmica), cognição (indicadores: qualidade e quantidade de conhecimento, desempenho acadêmico), atividade (indicadores: domínio das habilidades práticas, velocidade de execução das tarefas de treinamento). Os resultados do experimento pedagógico (incluindo a comparação dos resultados dos grupos experimental e controle) fundamentam a afirmação de que o treinamento de estudantes de veterinária com o uso de ferramentas de e-learning baseadas na visualização é mais eficaz do que o tradicional.

Palavras-chave: Visualização. Ferramentas de e-learning. Treinamento profissional. Latim.

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1 INTRODUCTION

Researchers have repeatedly drawn attention to the fact that modern e-learning tools have advanced features for better implementation of the didactic principle of visualization. The feasibility of the use of such tools is determined, primarily, by the opportunity to use them for the visualization of educational information, the formalization of knowledge about the objective world. However, existing studies mainly focus on the benefits of e-learning tools as for the implementation of the principle of visualization comparing to the traditional ones. A large number of recent studies on the subject have examined and a literature review is presented in the Theoretical Background section. The literature review shows that previous research examined the effects of visualization in science education, in particular in teaching and learning biology, math, physics, chemistry, as well as living languages – English, French, Chinese, etc. and only a few studies dealt with Latin. For this study, it was of interest to investigate the effect of using e-learning tools based on visualization on teaching and learning Latin by veterinary students. Specific research questions, hypotheses and criteria are formulated in the Research Questions section. Details of basic research methodology (participants and setting, design, data collection procedures) are given in the Method section. Key findings of the study are described in the Results and Analysis section and interpreted in light of previous research with a description of some limitations and open questions for further research – in the Final Considerations one.

1.1 THEORETICAL BACKGROUND

In this research, we understand visualization in the broad sense as "presentation of pictures showing easy to recognize objects that are connected through well-defined relations. It means the translation of mental, abstract, formal concepts into images by looking and seeing objects and processes" (URSYN, 2018, p.1).

Visualization is interpreted as an indicator of simplicity and clarity for the subject of a mental image created in the process of perception and subsequent mental processing of real objects; a tool based on visualization is considered as an external support of internal actions carried out in the learning process.

According to Gooding (2004, p.2), visual modes of representation are essential to the generation, communication, and dissemination of new knowledge.

Popkov and Korzhuev (2010), exploring the scientific basis of visualization principle in universities, emphasize the need to include the activities related to modeling, idealization, imaginary experimentation into the learning process. Scholars point out that the teacher has visual tools at his disposal that would provide an opportunity to show and find the very essential links and relations between the objects and

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phenomena under study and the values that describe them (not their individual minor manifestations), and the degree of influence of various factors and conditions on the natural phenomenon under study.

Shah and Freedman (2003) consider that the benefits of using visualization in learning environments are: promoting learning by providing an external representation of the information, deeper processing of information; maintaining learner attention by making the information more attractive and motivating.

Shatri & Buza (2017) proved, that the use of visualization in the teaching and learning process has a positive influence in increasing and developing the critical thinking of students.

Sankey, Birch and Gardiner (2010, p.853) noted that:

> the increasing use of multimedia in teaching has provided many opportunities to present multiple representations of content (text, video, audio, images, interactive elements) to cater more effectively to the different learning styles and modal preferences of an increasingly diverse student body.

If traditional learning visual aids required the specifics of the object under study, then computer technologies use allows the dynamic interpretation of essential properties not only of real objects, but also scientific laws, theories, concepts. According to research (VOLOSHINOV, 2011), such multimedia visualization allows creating a more progressive nature-like environment to display educational content, its visual interactive modeling and research; hypermedia architecture provides a person-focused, developing nature of education. The extraordinary expressiveness and visual appeal of multimedia are important in dealing with a new video-generation which easily absorbs knowledge through the works of computer culture. It forms students' tendency to perceive, to know the world through figurative and visual information presentation based on ICT, the readiness to work in the information society. Multimedia visualization is characterized by much greater informational density, the merge of conceptual and visual that organically embraces both verbal and creative thinking.

Also, e-tools provide the subjects of learning with the opportunity to perform transforming activity with the objects of learning, to observe and analyze its results, thus achieving a significant improvement of gnosticism models of objects under study. Thus, the principle of visual aids using in the studies of modern didacticians is interpreted not only with the availability of the object under study to perceive via observation but is supplemented by the requirements to attract the subject of learning to transform activity, accompanied by the visualization of its results (LAPINSKY, 2009; MADZIHON *et al.*, 2003).

Henderson (1999, p.237) to help explain why visual representations are so powerful, develops the concept of "metaindexicality" – the ability of visual representation, used interactively, to combine many

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diverse levels of knowledge and thus to serve as a meeting ground (and sometimes battleground) for many types of workers.

Other researchers believe that the damage from using multimedia tools in education is more apparent than the benefit. According to Afanasjev (2006), any use of visual aids in education is harmful when they replace students' independent imagination and thinking. The overuse of visual aids can cultivate "comics-thinking". In general, visual aids often initiate not the intellect but emotions, and therefore, they are convenient means of imposing opinions from the outside, while the education goal is to teach students to do it on their own. Useful visual aids should not replace, but rather initiate both imagination and human intelligence, expand and enrich the current experience. The researcher brings up an issue of whether modern ICT can involve a person into experience, which is hard to get, and in this way to make the person more developed, to expand the scope of independent thinking.

Didactic risks of visualization principle are the most predictable and are mentioned in the works of many contemporary scholars. While analyzing the e-learning tools the attention was repeatedly drawn to the typical overuse of visualization at the price of its content, semantic plan substitution with illustrations, eye-catching techniques, animation. The redundancy of illustrative component dissipates students' attention, distracts them from tracking the logic of content deployment.

So, using visualization in teaching and learning remains an open problem in the area. A number of questions regarding the use of e-learning tools based on visualization remain to be addressed.

Ursyn *et al.* (2016) researched knowledge visualization and visual literacy in science education, in particular in biology, math, digital media, and music; Janitor *et al.* (2010) examined the use of visual learning tools for teaching and learning computer networks, Volohsinov (2011) – for algorithmic training, Arcavi (2003) – the role of visual representations in the learning of math, Eilks *et al.* (2012) – the role of visualization and its potential danger for teaching and learning chemistry.

And although many scholars (FAHIM and VAEZI, 2011; HASHEMI and POURGHARIB, 2013; KOLODII *et al.*, 2017; HSIAO *et al.*, 2017; SADEGHI and FARZIZADEH, 2013) have studied the use of visualization in foreign language teaching and learning, most of these studies dealt with living foreign languages.

Despite the large numbers of studies examining various aspects of ICT use in teaching and learning Latin, only a few studies to date have focused on using visualization in this field, among which we should mention the work devoted reading proficiency in Latin through expectations and visualization (MARKUS; ROSS, 2004), and research of improving engagement and accuracy with the visualization of Latin for language learning (ZHOU, 2015). In particular, Zhou developed a special tool Ingenium, an interactive visual representation of grammatical concepts in Latin that focuses on grammatical forms over word order,

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redirecting students' attention from the meanings and functions of words in isolation to the grammatical interactions among all words in a sentence. And after an experiment, the researcher concluded that using Ingenium "not only improves students' understanding and translating of Latin sentences through its visual emphasis on grammatical concepts and structures, but also increases student engagement by providing a dynamic environment for experimentation" (ZHOU, 2015, p.69). These ideas were developed in other work by Zhou, Livingston, Schiefsky, Shieber, Gajos (2016), adapted Ingenium to be used for two standard classroom activities: sentence translations and fill-in-the-blank exercises. To our knowledge, no prior studies have examined the use of e-learning tools based on visualization in teaching and learning Latin in professional training.

1.2 RESEARCH QUESTIONS

The purpose of the experimental research work was to carry out the system of pedagogical impact by means of e-learning tools based on visualization and evaluate the effect of using such tools on teaching and learning Latin by veterinary students.

The following criteria have been established for the effectiveness of learning:

- motivation (indicators: focus and level of academic motivation),
- cognition (indicators: quality and amount of knowledge academic performance),
- activity (indicators: mastering practical skills, speed of execution of training tasks).

This study aims to answer the following research questions:

Q1: Does the use of e-learning tools based on visualization have a significant impact on the motivation of veterinary students in studying Latin?

Q2: Does the use of e-learning tools based on visualization have a significant impact on the cognition of veterinary students in studying Latin?

Q3: Does the use of e-learning tools based on visualization have a significant impact on the activity of veterinary students in studying Latin?

Q4: Is there a statistically significant difference in academic performances on Latin of students trained in traditional ways and students trained with a technique, providing for the complex use of traditional and e-learning tools, based on visualization?

Therefore, the main research hypothesis was:

H_0: The use of e-learning tools based on visualization has no effect on teaching and learning Latin by veterinary students.

It was specified in the following working hypotheses:

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$H_0$1: The use of e-learning tools based on visualization doesn't have any significant impact on the motivation of veterinary students in studying Latin.

$H_0$2: The use of e-learning tools based on visualization doesn't have any significant impact on the cognition in studying Latin.

$H_0$3: The use of e-learning tools based on visualization doesn't have any significant impact on the activity in studying Latin.

$H_0$4: There is no significant difference in academic performances on Latin of students trained in traditional ways and students trained with a technique, providing for the complex use of traditional and e-learning tools, based on visualization.

2 METHOD

To evaluate the effectiveness of e-learning tools based on visualization the pedagogical experiment was conducted in three Ukrainian agrarian universities: National University of Life and Environmental Sciences of Ukraine (Kyiv), Podilsky State Agrarian and Technical University (Kamyanets-Podilsky), Poltava State Agrarian Academy (Poltava).

2.1 PARTICIPANTS AND SETTING

The experiment lasted 4 years (from 2016 to 2019) and consisted of three stages. At the first stage, we examined the status and trends in teaching with using e-learning tools in agrarian universities, diagnosed students' needs on the use of e-learning tools and defined experimental and control groups. A total 247 veterinary students (109 male and 138 female) from Ukrainian agrarian universities participated in the experiment. 6 teachers (2 senior lecturers and 4 associate professors) were involved in experimental work. Defining the research problem, methodology, experimental design, developing instruments, data collection and analysis were carried out by the author in the framework of Ph.D. thesis (BALALAIEVA, 2016).

At the beginning of the experiment, there were not any considerable differences between levels of indicators among students of the control and experimental groups, because they did not have a background and prior knowledge in the Latin (this language is not studied in schools in Ukraine), that made it possible to ensure the homogeneity of the group composition.

At the second stage, under the experimental conditions, students of the control group (n=124) were trained in traditional ways; students of the experimental group (n=123) were trained with a new

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technique, providing for the complex use of traditional learning tools, some online resources and software as well as special e-textbook «Elementa Linguae Latinae», based on visualization. Online resources and software were selected by such criteria as accuracy, credibility, reasonableness, support, interactivity, aesthetics, accessibility, communicative, pragmatic and cognitive value (BALALAIEVA, 2019).

The e-textbook "Elementa Linguae Latinae" was designed taking into account major principles of teaching Latin at the Faculty of Veterinarian Medicine, objective factors (students' provision of learning materials, academic performance and motivation, normatively defined goals with defined priorities in developing competencies) and subjective factors (student preferences). Its purpose, tasks, macro- and microstructure, interface are described in detail in the previous author's articles (BALALAIEVA, 2016; 2017),

One of an important feature of this e-textbook is the consistent use of cognitive visualization tools in the delivery of the training material, such as cognitive-graphic models, schemes, etc. (see figure 1).

Figure 1 – Example of task on Latin based on the visualization

The use of cognitive visualization techniques is relevant specifically for electronic guides designed to help master the discipline and provide solutions to local pedagogical problems: supplementing the material of the basic textbook, repeating and systematizing the acquired knowledge, providing additional or reference information on a specific topic, etc.

At the third stage, quantitative and qualitative analysis of empirical data were carried out, results of the research were systematized and generalized.

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2.2 DATA COLLECTION

The experiment was conducted under the conditions of a real educational process, all samples are based on homogeneous student contingent, the classes in control and experimental groups were given by the same teachers by single work program, measurements in control and experimental groups were carried out synchronously with unified instruments and were evaluated on the same criteria, that in the complex contributed to ensuring the reliability of the results of experimental research. In general, the reliability of the results of research is ensured by the theoretical reasonableness of the research positions, the application of a complex of valid methods that are adequate to its purpose and objectives, quantitative and qualitative analysis of theoretical material and empirical data, mathematical-statistical methods for processing and interpretation of the results of the formative stage of the experiment.

The instrument to examine the motivational orientation in the learning Latin was developed based on Dubovitskaya (2002) methodology of diagnosis of focus and levels (low, medium, high) of educational motivation, intended for all categories of students older than 12. It was modified and adapted to the conditions of the current experiment. The developed survey consisted of 20 items. The pilot survey was conducted in a representative group (n=12). Students were asked to indicate their level of agreement or disagreement with statements on a 4-point Likert scale: strongly disagree, disagree, agree, and strongly agree. Item reliability has been assessed by calculating Cronbach's alpha (α=0.82, SPSS). After revising problematic items a survey (Appendix A) was proposed to students at the beginning and at the end of the experiment. Data were correlated. The results are described below (see Results).

Also, students of experimental and control groups were evaluated through a system of standardized achievement tests in the Latin language. Based on the results of the three tests (by different modules), the student average scores were calculated, which formed the basis of two independent samples (total sample size – 247). To test the hypothesis about the coincidence of the characteristics of the two groups, in particular, to determine whether there is a significant difference between the values of indicators of academic progress of students in control and experimental groups, as these differences are reliable and whether they could be extrapolated to the whole population t-test was applied.

To evaluate the learning effectiveness, the methodology of Bespalko (1999) for determining the coefficient of mastering the educational material (K_a) with standard values for 3 levels: low ($K_a < 0.7$), medium ($0.7 \leq K_a < 0.85$), high ($0{,}85 \leq K_a \leq 1$) was used. The measurement of the speed of execution of training tasks was carried out according to the actual time required for a student to complete one test. To determine the levels of test execution speed (V_t) following limits were accepted: low ($V_t \geq 80$ min),

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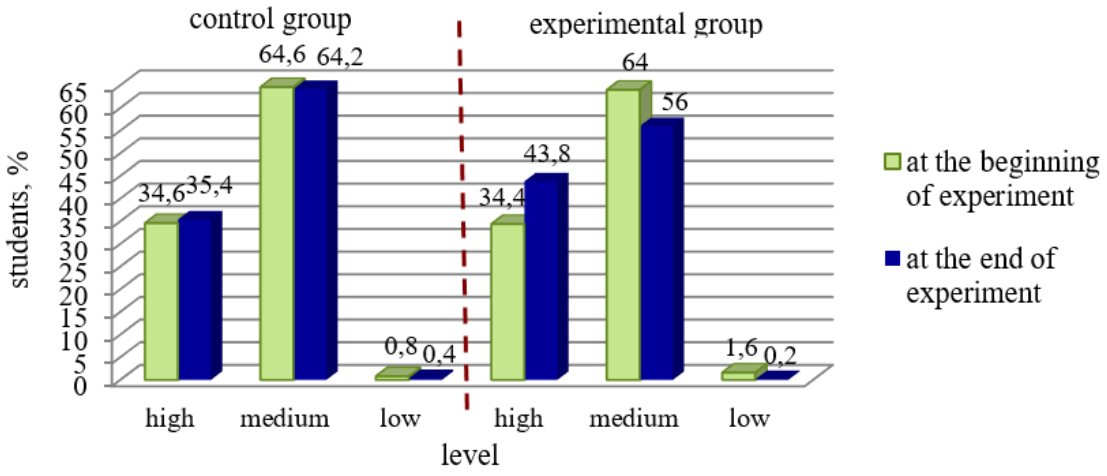
medium (60 min < V_t < 80 min), high V_t < 60 min. Data reliability was checked by using statistical analysis with Pearson's chi-squared test.

3 RESULTS AND ANALYSIS

Comparative analysis of the dynamics of educational motivation showed that the difference in the growth of the number of students with dominating intrinsic motives is 10.4% for the experimental group. It is proved that positive changes have occurred in the redistribution of motivation levels: in experimental group number of students with a low level of motivation decreased by 1.4%, with a high level of motivation increased by 9.4%; in control one the number of students with a low level of motivation decreased by 0.4%, with high level increased by 0.8% (figure 2).

Figure 2 – Comparative diagram of the distribution of intrinsic motivation levels in the control and experimental groups at the beginning and end of the experiment



To test the hypothesis about the coincidence of the characteristics of the two groups, in particular, to determine whether there is a significant difference between the significant values of indicators of academic progress of students in control and experimental groups, as these differences are reliable and whether they could be extrapolated to the whole generation was applied *t*-test (Appendix B). The positive difference in learning was ascertained in the experimental group: the number of students with medium and high levels of academic progress increased. In particular, the number of students with low progress

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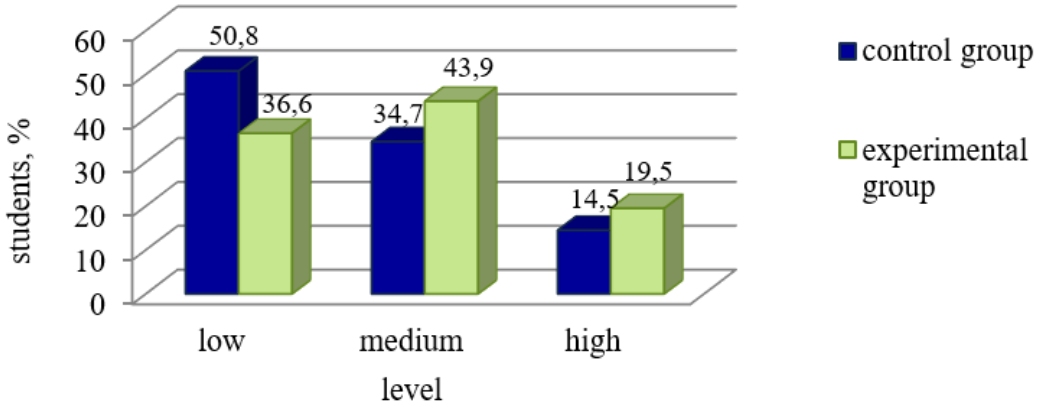
in the experimental group is 14.2% less than in the control one, but the number of students with medium and high levels of academic progress higher by 9.2% and 5% respectively (see figure 3).

Figure 3 – Comparative diagram of levels of academic progress in the control and experimental groups



In general, by the results of the statistical analysis, the average score in the experimental group is 0.51 higher than in the control one.

Table 1 – Data on test results in control and experimental groups

	Test 1		Test 2		Test 3		Average	
	Cg*	Eg**	Cg	Eg	Cg	Eg	Cg	Eg
GPA	5,0	5,37	4,81	5,45	5,10	5,64	4,97	5,48
Dispersion	2,32	2,09	2,29	2,46	2,25	2,00	2,28	2,18
Coefficient of variation	0,3	0,27	0,31	0,28	0,28	0,24	0,29	0,26

Cg* - control group

Eg** - experimental group

Also it was determined that most of the students both in control and experimental groups demonstrated low speed of execution of training tasks; but in experimental group the number of students with medium speed of execution of training tasks is 9.2% greater than in control one, as well 6.4% of students showed a high speed of execution of training tasks (see figure 4).

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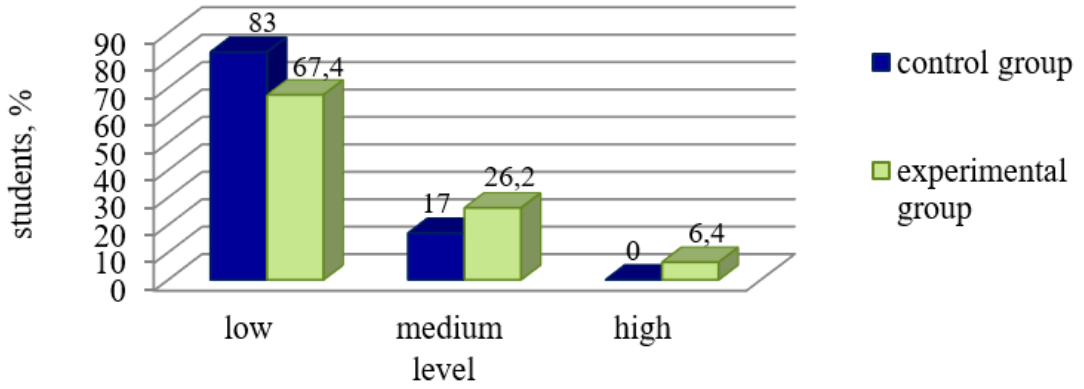
Figure 4 – Comparative diagram of levels of speed of execution of training tasks in the control and experimental groups



It was found that the overall speed of execution of training tasks in the experimental group is 7.8% higher than in the control one (reliability is confirmed by using statistical analysis with Pearson's chi-squared test in Appendix C).

The results of the pedagogical experiment give the grounds to state that training veterinary students with using e-learning tools based on visualization is more effective than traditional one.

4 FINAL CONSIDERATIONS

Thus, the experiment has proved the positive statistically significant effect of using e-learning tools based on visualization on teaching and learning Latin by all criteria: motivation, cognition and activity. The null hypothesis H_0, stating that the use of e-learning tools based on visualization has no effect on teaching and learning Latin by veterinary students was rejected.

The results of this study are in line with the findings of a research performed by Zhou (2015), who conducted the experiment with 67 beginning Latin students, measuring objective emotional and cognitive engagement, learning, change in self-efficacy, cognitive load, accuracy in sentence translation and concluded, that students when using interactive visual tool reported considerably higher levels of engagement and learning, opted to perform more optional problems, and completed translation exercises with substantially greater accuracy than when using the traditional interface.

In particular, positive change dynamics have been discovered in learning motivation focus and in intrinsic motivation levels redistribution. These findings allow us to reject the hypothesis $H_0$1: the use

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of e-learning tools based on visualization doesn't have any significant impact on the motivation of veterinary students in studying Latin. This result ties well with previous studies demonstrating a positive influence of visualization in students' motivation both in science education (SANKEY *et al.*, 2010; EILKS *et al.*, 2014; URSYN, 2016; SHATRI & BUZA, 2017) and foreign languages teaching and learning (HASHEMI & POURGHARIB, 2013; SADEGHI *et al.*, 2013; HSIAO *et al.*, 2017; KOLODII *et al.*, 2017).

Concerning Latin, Zhou (2015) proved that visual tools can increase student emotional and cognitive engagement with grammar, Markus and Ross (2004) – with reading. In the same line, Zhou *et al.* (2016) showed that students reported a greater positive change in self-efficacy related to Latin grammar and reading comprehension after using tools based on visualization than after using the traditional text-only versions of the exercises. Self-efficacy, or task-related confidence, is an effective predictor of motivation (ZHOU *et al.*, 2016, p.12)

The results of the analysis by cognitive criterion allow us to reject the hypothesis $H_0$2: the use of e-learning tools based on visualization doesn't have any significant impact on the cognition in studying Latin. This result is consistent with research by Zhou *et al.* (2016) showing that students reported reflecting more on the grammar of the sentences when using interactive visual tool than when solving the traditional text-only versions of the exercises. In the previous work Zhou (2015, p.60) showed that participants reported approximately equal levels of cognitive load in the experimental and control conditions.

Also, it was found that the overall speed of execution of training tasks and accuracy in terminological translation in the experimental group was higher than in the control one and this difference was statistically significant, that allows us to reject the hypothesis $H_0$3: the use of e-learning tools based on visualization doesn't have any significant impact on the activity in studying Latin. A similar conclusion was reached by Zhou (2015, p. 3), stating that students, when using visual tool Ingenium, completed translation exercises with substantially greater accuracy than when using the traditional interface.

The effectiveness of e-learning tools using has been proved by a statistically significant increasing academic performance in experimental groups (in general, the average score in the experimental array is 0.51 higher than in the control one). So, hypothesis $H_0$4, stating that there is no significant difference in academic performances on Latin of students trained in traditional ways and students trained with a technique, providing for the complex use of traditional and e-learning tools, based on visualization, was also rejected. These results are in accordance with findings reported by Zhou (2015), proving that students reported a higher level of learning Latin in the experimental conditions when using interactive visual tool.

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But why the difference between the indicators of the control and experimental groups on cognition and activity criteria was significant but not as large as expected? There are many reasons for this.

In our opinion, the potential of modern e-learning tools not only allow the implementation of visualization principle on a whole new level but also significantly increase the didactic risks of its realization (BALALAIEVA, 2016).

Ageyev and Drevs (2003) point out the following disadvantages e-learning tools: users hold a dialogue through the display in a static working position, in the conditions of time shortage, which requires higher attention concentration and intense mental activity in the process of multi-dimensionless analysis of display formats and processing algorithms of visual information arrays, that are large in size and different in structure.

The objective shortcomings of computer learning tools (the need to have a computer with respective software and to be able to work on it; the difficulty to perceive large arrays of textual material from the screen; the lack of interactivity of computer learning tools) are often accompanied by subjective disadvantages caused by the conceptual errors in the design of certain e-learning tools.

The ergonomic requirements for e-learning tools determine the necessity to consider the age and the individual characteristics of users, different ways of thinking and nervous activity organization, and the patterns of intellectual and emotional rehabilitation. To reduce the load on visual analyzers while designing an e-learning tool it is necessary to consider physiological and ergonomic requirements for material visualization (colors, the spatial layout of information on the screen, the organization of alphanumeric characters, and symbols on the screen, image legibility and resolution, etc.).

Equally important is the danger which lies in pedagogically unjustified use of modern information technologies. According to Robert (2010), it is more common than sanitary rules violations.

The use of e-learning tools, developed with the violation of design-ergonomic and hygiene requirements, put the physical and mental health of users at risk.

The researchers note that attempts to interest via excessive use of animation and gaming tools do not achieve the desired goal primarily due to the "contrast effect" (AGEEV and DREVS, 2003, p. 120), when the student is familiar with dynamic computer games and simulators and expects the same dynamics from the e-learning tools.

The desire to make e-textbook bright and eye-catching out of ignorance of basic rules of font science, chromatics, composition, design leads to the opposite effect – it complicates the perception and understanding of information (sometimes to complete unreadableness). We also note that e-learning tools often use ready-made illustrative materials from different databases, resulting in that the manual

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includes various pictures, photos, video clips of questionable didactic potential; they are all different in technique, quality and purpose. Illustrative material should not contain extra information that distracts the students from absorbing the knowledge; the same-type illustration should be performed in the same technique.

Researchers (LAPINSKY, 2009) set out the requirements for software and computer systems of educational purpose that complement and extend the principle of visualization:

- tools should contain such a visual model of the object that best contributes to the learning goal, without excessive details or simplifying the overall image plans;
- a model should be presented in a form that allows most clearly identify and distinguish links and relationships components of an object;
- cognition (stimulation of guessing) of educational material with visual aids should be implemented so as to enable the teacher to use the methods of active learning, and to make the learning process really interactive;
- gnosticism of presenting educational models cannot be a goal in itself: it is necessary to use models of objects under study that do not present knowledge in a completed form but include research, the independent cognitive activity of students, encouraging their skills for such activities.

Scholars (MADZIHON *et al.*, 2003) believe that modern understanding of visualization principle with using educational software creates significant didactic prerequisites for success in learning through emotional inclusion, gnosticism, the visualization of the information perception process, a dosage of multimodality of educational influences that encourage voluntary attention and use suggestive memory, individualization of educational information presentation pace. When creating and analyzing visual models, the subjects of learning have to undergo phases of scientific knowledge – to carry out system decomposition, the analysis of its components, the selection of essential features of objects and essential connections between them – with the subsequent determination of model's structure or the object and its synthesis.

Thus, the major advantages of e-learning tools for the implementation visualization principle are: the opportunity of abstract visual-figurative interpretation of essential properties of real objects, scientific laws, theories, concepts, providing a poly-sensorial perception of educational information, and the opportunity to carry out the transforming activity with objects or their models. However, the potentials of modern e-learning tools not only allow the implementation of the visualization principle on a whole new level but also significantly increase the didactic risk of its realization. To prevent such risks while

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designing the e-learning tools it is necessary to be guided by the requirement of reasonable visualization sufficiency – a necessary optimal minimum of illustrative material which has to be determined individually for each tool, depending on its purpose, functions in the learning process, target audience etc.

Despite all disadvantages and risks, we agree with modern researches (URSYN, 2018), that visual approach to learning is objective necessary today and fully share following opinion:

> notwithstanding individual differences in intelligence and learning style, this generation of children needs to be taught the way they learn best – with visual stimulation accompanied by active learning strategies. As educators, we need to prepare our students for the world in which they will live and work. We must allow this understanding of the visual nature of our students to influence our teaching techniques and the educational technologies we employ (GANGWER, 2015, p. 4).

In summary, the importance of this study is that it contributes to teaching and learning Latin in professional training by introducing the innovative research-based technique, providing for the complex use of traditional and e-learning tools, based on visualization.

The ways to minimize didactic risks that may result from inappropriate (from psychological and educational points of view) use of visual aids in e-learning tools are outlined.

The practical findings of this work were discussed and implemented into the educational process of Podilsky State Agrarian and Technical University (Certificate No. 75-01-388), Poltava State Agrarian Academy (Certificate No. 01-06/73), National University of Life and Environmental Sciences of Ukraine (BALALAIEVA, 2016).

Although the research has reached its aims, there were some unavoidable limitations. First, the experiment was conducted only in Ukrainian agrarian universities.

To make a greater contribution to practical experience the result should be compared with similar studies in different countries, because our findings may not be applicable to other universities.

Second, the sample size was large enough for our local study, but it may be too small and non-representative for the larger population. Also, the sample was too homogeneous (all participants were students of the same faculty of veterinary medicine) and may not be representative of students at other faculties.

Finally, the study was focused on Latin language teaching; this methodology is rather specific and has certain limitations in the formation of linguistic competencies in comparison with teaching live foreign languages that involve active communicative activity.

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Further research should have a greater number of participants of different ages, from different faculties and universities and be conducted based on different languages to yield more generalizable results.

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APPENDICES

Appendix A. Survey on motivational orientation of students in learning Latin

Item	Strongly disagree	Disagree	Agree	Strongly agree
I need Latin for my future profession.			+	
I see no prospect of studying dead language; in practice I do not need it.		+		
I believe that the Latin language course is required at any medical faculty.			+	
There is no need for academic subject "Latin language" because Latin terminology is studied at lectures and lab works on special subjects.	+			
The Latin is interesting to me, and I want to know as much as possible about it.			+	
Latin grammar and exercises are uninteresting to me; I do them, because the teacher requires it.		+		
Knowledge that I get in Latin classes is enough for me.		+		
The desire to pass an examination and receive grants is a main stimulus of studying Latin for me.	+			
I believe that theoretical issues of this subject could not be studied.		+		
Difficulties in learning Latin do it more interesting for me.	+			
I do all the tasks by myself, I do not like when somebody helps me.			+	
I can do tasks by myself, but I have to force myself to do it.			+	
When it's possible, I try to crib colleagues' answers or ask them do the works for me.	+			
If I did not understand the material in class, I do not try to learn it by myself.				+
I'm upset when I am not prepared for Latin classes or miss them.			+	
If I had the opportunity to choose subjects for study, I would choose Latin.			+	
It doesn't matter what discipline to study for me, I try to be the best among students.		+		
Auxiliary explanations of difficult cases in Latin grammar could be raised my interest in this subject.				+
I often do not understand teacher explanations and am ashamed to ask again, although I wish to know as much as possible.			+	
I read more books and use online resources to better understand Latin grammar and terminology.			+	

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Appendix B. Results of t-test

	Control group			Experimental group		
Student number	**GPA**	**Deviation**	**Std. deviation**	**GPA**	**Deviation**	**Std. deviation**
1	6.2	1.23	1.5129	8.1	2.62	6.8644
2	5.7	0.73	0.5329	4.4	-1.08	1.1664
3	4.3	-0.67	0.4489	5.2	-0.28	0.0784
4	5.2	0.23	0.0529	3.5	-1.98	3.9204
5	4.1	-0.87	0.7569	4.0	-1.48	2.1904
6	7.2	2.23	4.9729	8.0	2.52	6.3504
7	3.5	-1.47	2.1609	7.0	1.52	2.3104
8	6.2	1.23	1.5129	4.2	-1.28	1.6384
9	3.8	-1.17	1.3689	6.2	0.72	0.5184
10	6.4	1.43	2.0449	3.8	-1.68	2.8224
11	2.5	-2.47	6.1009	6.1	0.62	0.3844
12	5.9	0.93	0.8649	3.9	-1.58	2.4964
13	4.6	-0.37	0.1369	7.2	1.72	2.9584
14	6.1	1.13	1.2769	3.8	-1.68	2.8224
15	7.5	2.53	6.4009	6.9	1.42	2.0164
16	3.2	-1.77	3.1329	5.7	0.22	0.0484
17	4.4	-0.57	0.3249	5.2	-0.28	0.0784
18	7.7	2.73	7.4529	4.9	-0.58	0.3364
19	6.5	1.53	2.3409	4.8	-0.68	0.4624
20	3.2	-1.77	3.1329	6.2	0.72	0.5184
21	4.5	-0.47	0.2209	6.8	1.32	1.7424
22	4.7	-0.27	0.0729	3.5	-1.98	3.9204
23	5.7	0.73	0.5329	4.4	-1.08	1.1664
24	5.7	0.73	0.5329	6.5	1.02	1.0404
25	2.4	-2.57	6.6049	3.8	-1.68	2.8224
26	4.4	-0.57	0.3249	3.5	-1.98	3.9204
27	4.7	-0.27	0.0729	5.2	-0.28	0.0784

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28	6.5	1.53	2.3409	3.5	-1.98	3.9204
29	6.4	1.43	2.0449	8.3	2.82	7.9524
30	3.8	-1.17	1.3689	7.2	1.72	2.9584
31	3.7	-1.27	1.6129	4.8	-0.68	0.4624
32	3.6	-1.37	1.8769	3.6	-1.88	3.5344
33	7.3	2.33	5.4289	5.2	-0.28	0.0784
34	7.2	2.23	4.9729	2.5	-2.98	8.8804
35	4.8	-0.17	0.0289	6.9	1.42	2.0164
36	3.6	-1.37	1.8769	4.7	-0.78	0.6084
37	5.2	0.23	0.0529	6.5	1.02	1.0404
38	2.5	-2.47	6.1009	6.4	0.92	0.8464
39	6.9	1.93	3.7249	3.8	-1.68	2.8224
40	3.5	-1.47	2.1609	3.7	-1.78	3.1684
41	5.2	0.23	0.0529	3.6	-1.88	3.5344
42	3.5	-1.47	2.1609	7.2	1.72	2.9584
43	7.2	2.23	4.9729	5.6	0.12	0.0144
44	5.6	0.63	0.3969	6.0	0.52	0.2704
45	5	0.03	0.0009	5.2	-0.28	0.0784
46	5.2	0.23	0.0529	5.5	0.02	0.0004
47	5.5	0.53	0.2809	6.2	0.72	0.5184
48	6.2	1.23	1.5129	4.4	-1.08	1.1664
49	4.4	-0.57	0.3249	7.2	1.72	2.9584
50	5.2	0.23	0.0529	5.4	-0.08	0.0064
51	3.6	-1.37	1.8769	7.5	2.02	4.0804
52	2.6	-2.37	5.6169	6.5	1.02	1.0404
53	7.3	2.33	5.4289	6.8	1.32	1.7424
54	7.0	2.03	4.1209	7.1	1.62	2.6244
55	3.5	-1.47	2.1609	3.7	-1.78	3.1684
56	6.2	1.23	1.5129	4.4	-1.08	1.1664
57	3.5	-1.47	2.1609	7.3	1.82	3.3124

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58	4.4	-0.57	0.3249	7.9	2.42	5.8564
59	2.7	-2.27	5.1529	5.7	0.22	0.0484
60	5.5	0.53	0.2809	3.6	-1.88	3.5344
61	3.6	-1.37	1.8769	4.5	-0.98	0.9604
62	6.1	1.13	1.2769	5.2	-0.28	0.0784
63	5.7	0.73	0.5329	4.1	-1.38	1.9044
64	2.4	-2.57	6.6049	7.3	1.82	3.3124
65	4.4	-0.57	0.3249	6.2	0.72	0.5184
66	4.7	-0.27	0.0729	7.9	2.42	5.8564
67	6.5	1.53	2.3409	5.2	-0.28	0.0784
68	6.8	1.83	3.3489	6.9	1.42	2.0164
69	3.5	-1.47	2.1609	7.1	1.62	2.6244
70	4.1	-0.87	0.7569	5.7	0.22	0.0484
71	5.4	0.43	0.1849	3.9	-1.58	2.4964
72	7.2	2.23	4.9729	3.5	-1.98	3.9204
73	5.5	0.53	0.2809	4.6	-0.88	0.7744
74	3.8	-1.17	1.3689	4.5	-0.98	0.9604
75	6.9	1.93	3.7249	5.2	-0.28	0.0784
76	5.7	0.73	0.5329	4.5	-0.98	0.9604
77	2.7	-2.27	5.1529	7.6	2.12	4.4944
78	4.9	-0.07	0.0049	6.2	0.72	0.5184
79	4.8	-0.17	0.0289	7.9	2.42	5.8564
80	6.2	1.23	1.5129	4.1	-1.38	1.9044
81	6.8	1.83	3.3489	6.6	1.12	1.2544
82	3.5	-1.47	2.1609	7.5	2.02	4.0804
83	4.4	-0.57	0.3249	6.3	0.82	0.6724
84	5.4	0.43	0.1849	3.9	-1.58	2.4964
85	4.4	-0.57	0.3249	5.4	-0.08	0.0064
86	5.2	0.23	0.0529	7.9	2.42	5.8564
87	3.5	-1.47	2.1609	6.5	1.02	1.0404

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88	3.0	-1.97	3.8809	6.8	1.32	1.7424
89	8.0	3.03	9.1809	7.1	1.62	2.6244
90	7.0	2.03	4.1209	3.6	-1.88	3.5344
91	4.2	-0.77	0.5929	4.5	-0.98	0.9604
92	6.2	1.23	1.5129	5.9	0.42	0.1764
93	3.2	-1.77	3.1329	7.8	2.32	5.3824
94	5.1	0.13	0.0169	5.7	0.22	0.0484
95	2.9	-2.07	4.2849	3.6	-1.88	3.5344
96	4.4	-0.57	0.3249	4.1	-1.38	1.9044
97	6.8	1.83	3.3489	6.1	0.62	0.3844
98	2.7	-2.27	5.1529	7.9	2.42	5.8564
99	5.3	0.33	0.1089	3.2	-2.28	5.1984
100	3.5	-1.47	2.1609	4.5	-0.98	0.9604
101	2.7	-2.27	5.1529	4.5	-0.98	0.9604
102	4.9	-0.07	0.0049	7.3	1.82	3.3124
103	6.7	1.73	2.9929	6.2	0.72	0.5184
104	7.7	2.73	7.4529	5.7	0.22	0.0484
105	6.0	1.03	1.0609	3.9	-1.58	2.4964
106	4.4	-0.57	0.3249	5.3	-0.18	0.0324
107	2.8	-2.17	4.7089	4.1	-1.38	1.9044
108	3.7	-1.27	1.6129	7.6	2.12	4.4944
109	5.4	0.43	0.1849	6.7	1.22	1.4884
110	4.5	-0.47	0.2209	4.2	-1.28	1.6384
111	6.1	1.13	1.2769	5.3	-0.18	0.0324
112	7.9	2.93	8.5849	3.5	-1.98	3.9204
113	3.2	-1.77	3.1329	4.0	-1.48	2.1904
114	4.5	-0.47	0.2209	4.9	-0.58	0.3364
115	4.5	-0.47	0.2209	7.2	1.72	2.9584
116	7.3	2.33	5.4289	4.7	-0.78	0.6084
117	6.2	1.23	1.5129	6.0	0.52	0.2704

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118	5.7	0.73	0.5329	4.4	-1.08	1.1664
119	3.9	-1.07	1.1449	3.8	-1.68	2.8224
120	5.3	0.33	0.1089	2.9	-2.58	6.6564
121	4.4	-0.57	0.3249	7.4	1.92	3.6864
122	4.5	-0.47	0.2209	6.5	1.02	1.0404
123	2.9	-2.07	4.2849	4.6	-0.88	0.7744
124	3.8	-1.17	1.3689			
Sum	616	-0.28	262.4516	674.4	0.36	261.4752
Average	4.97			5.48		

Result: t = 2.7 degrees of freedom – 246

p≤0.05(1.96); p≤0.01 (2.58)

2.7 > 1.96; 2.7 > 2.58

Appendix C. Results of Pearson's chi-squared test

	Observed (empirical) frequency	Expected (theoretical) frequency	(ƒo - ƒe)	(ƒo - ƒe)2	(ƒo - ƒe)2/ƒe
1	2	3	4	5	6
1A	99	90	9	81	0.9
2B	81	90	-9	81	0.9
3C	21	26	-5	25	0.96
4D	31	26	5	25	0.96
5E	0	4	-4	16	4
	8	4	4	16	4
Sum	120	120	-	-	11.72