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Effectiveness of generative learning strategies based on mobile learning technologies in higher education

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ABSTRACT

The paper aims to comprehensively assess the effectiveness of generative learning strategies (GLS) using mobile learning technologies (MLT) in higher education, based on a quasi-experiment and quantitative and qualitative analysis. Methods included concept mapping, round table discussions, monitoring, computer testing, and statistical analysis. GLS with MLT demonstrated enhanced performance in Practical Ukrainian and English Language Courses. MLT-based GLS optimized teacher workload by reducing assignment checking time. Respondents rated MLT-based GLS for Ukrainian/English at 7.8/10. Effective methods included self-review, text correction, and concept mapping. The study validates MLT-based GLS in higher education, improving student performance and easing teacher tasks. Further research is planned for literature studies.

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1. INTRODUCTION

The modern paradigm of education is aimed at achieving the maximum effectiveness of education by using several factors, strategies, and tools that increase the productivity of learning. The role of those pedagogical methods that, as much as possible, involve the students in learning and acquiring the competencies necessary for the profession is growing against the background of the dominance of active learning. Generative learning strategies (GLS) are based on a constructivist approach to education as an active construction process based on an individual's prior knowledge [1]. Constructive learning means meaningful educational activity when the students actively build a mental model of the system they are studying [1], [2]. Constructionism (referring to what the student does) is contrasted with instructionalism or prescriptive learning (referring to what the instructor/teacher does).

The term constructivism is often used to denote discovery learning. In contrast to passive learning, constructionism in education contrasts learning based on what is said (direct instruction) and learning through

self-discovery (in which students build the rules and relationships they need). This contrast is also between following the instructions during direct learning and the independent work of the student who builds or discovers new knowledge. Generative strategies encourage students to create something meaningful on their own based on the material, topic, section previously studied with the teacher or on the independent processing of educational materials [3]–[7]. This definition distinguishes GLS from other popular learning strategies, which also require activity from students, but do not require the creation of additional content (for example, simply identifying the main point in the text, paraphrasing) [8]–[10].

The problem of the successful use of generative strategies is adjacent to the problems in the paradigm of modern higher education in Ukraine and the world. In particular, it is about matching educational models in higher education institutions (HEIs) to advanced educational standards. The analysis of several studies gives grounds to state that the niche of higher education today is one of the most problematic in the entire educational system. Radical restructuring will require a thorough reform of the teaching system in HEIs [11]–[13]. At the level of implementation of the latest approaches to learning in the educational process, every teacher of HEIs can implement qualitative changes in cooperation with students. One of the areas of reform is optimizing the education process-learning as much as possible in the shortest possible period. In this context, both the issue of GLS and the application of mobile learning technologies (MLT) for the education of HEI students are relevant. On the one hand, they solve the problem of improving training effectiveness, optimizing educational processes, and integrating higher education into the latest paradigm of general educational trends [14], [15].

The issues that still need to be resolved, as they have not been studied collectively, are: i) Possibilities of using generative strategies based on mobile applications for teaching higher school students (variety of methods, approaches to integration into the educational process); ii) The effectiveness of applying GLS compared to the traditional way of organizing the educational process; and iii) Higher school students' reflections on the effectiveness and comfort of learning based on MLT-based GLS.

The aim of this research is to comprehensively investigate the effectiveness of MLT-based GLS in higher education. The aim involves the fulfilment of the following research objectives. First, develop an algorithm for the implementation of GLS for teaching higher school students, taking into account the current features of higher education. Second, donduct a quasi-experiment based on measuring the effectiveness of MLT-based GLS. Lastly, based on the quantitative and qualitative analysis of the obtained empirical data, conclude the effectiveness of applying MLT-based GLS to improve the effectiveness of education of higher school students.

2. LITERATURE REVIEW

The methodological foundation for this research is built upon the previous study [8], which compares the effectiveness of linear learning strategies with generative ones based on a comparison of the effectiveness of knowledge acquisition as a result of simply reading the text (linear strategy) and mentally reorganizing the material into a coherent structure during reading (generative strategy). The generative strategy will hypothetically give better learning outcomes in all cases [9]–[11]. GLS is designed to make learning more effective. They encourage students to actively think about the material to be learned [1].

Generative learning theory identifies three cognitive processes that operate in memory during learning. They are selection, arrangement, and integration. The selection process involves students paying attention to relevant information in the learning material, for example, distinguishing the elements that are compared in the text. The arrangement process means creating an agreed structure of input information its arrangement by students. The integration process refers to the process by which students connect new information and prior knowledge activated from long-term memory [8].

It is important that generative learning is based on the theory that the learning process depends on memory and knowledge that already exists in the human mind [12]. When new data is integrated into long-term memory, it becomes part of a new, improved level of understanding [13]. Instead of consolidating mental representations, generative activity performs the function of building coherent mental representations. Combining generative strategies with students' retrieval practice is effective [14], [15]. Generative activity and search practice functionally complement each other and contribute to lasting learning [14]–[17].

The generative learning theory is based on the hypothesis that the human brain does not only passively observe events or the environment. On the contrary, it shapes its perception of experiences, scenarios, and problems [18]. Generative learning strategies differ from traditional (linear) learning strategies as they are learning methods that allow students to create new information instead of simply memorizing existing facts. These strategies enable students to interact with the material actively, using their knowledge and experience to solve new problems [19], [20]. The popular generative strategies are: i) explanation: students should explain the material in their own words; ii) teaching others: "reciprocal learning" when

students teach other students; iii) generating questions: students generate questions based on the material they are studying; iv) problem solving, which includes the practical application of new material and the involvement of critical thinking tools; v) creation: students create something new using their knowledge and experience (writing an essay, creating a presentation or project) [9], [19]–[22].

Several studies [23], [24] explored generative techniques in the context of immersive learning, concluding that generative learning strategies are particularly relevant for immersive virtual reality (IVR) simulations for education. A noticeable positive effect was noted on intrinsic motivation, perceived enjoyment, and presence. Additionally, the research noted a tangible increase in perceived enjoyment among learners engaging with generative techniques in immersive virtual reality settings. This finding aligns with the idea that when educational experiences are enjoyable, students are more likely to be actively engaged and motivated to participate in the learning process.

Hypothetically, using mobile technologies can significantly improve the effectiveness of GLS. However, MLT and GLS have not been studied in interaction so far, as evidenced by the review of current academic literature on the topic carried out by the authors of this article. Studying the educational potential of mobile learning is a relatively new area of research [25], [26]. The role of mobile technologies in achieving cooperation between the teacher and students was determined [27]–[30] to be of particular interest to those who explore how the potential of mobile technologies can be used for language teaching and learning in task-based language teaching.

3. RESEARCH METHOD

3.1. Research design

It was decided to focus on the study of the effectiveness of using MLT-based GLS for teaching Practical Ukrainian Language Course and Practical English Language Course to first-year students: i) at the Faculty of Ukrainian Philology and Journalism of Luhansk Taras Shevchenko National University (specialty 014.01); ii) at Mykhailo Stelmakh Faculty of Philology and Journalism of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University (specialty 014.01).

The first stage of the research (June 2021-August 2021) involved forming a working and expert group for the study. The working group included the article's authors, and the expert group included three representatives each from Luhansk Taras Shevchenko National University and Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University. The working group developed a research procedure based on the study of previous experience in the use of MLT-based GLS. An expert group validated it.

The second stage (September 2021) provided for selecting participants in the experiment. The previous students' performance data were also systematized at this stage based on summarizing the results of the external independent assessment. The students completed it for admission to their chosen majors at the specified HEIs.

The third stage (September 2021-June 2022) provided for the use of MLT-based GLS implemented in the educational process of the experimental group. The control group studied the same material but without emphasizing MLT-based GLS. During the implementation of the experimental part, meetings of working and expert groups (in online or mixed format) were held once a month for the interim agreement of the experiment's strategy and the current steps of its implementation.

The fourth stage of the research (July 2022) involved final computer-assisted testing using tests of external independent assessment of previous years. Typical test structures can be found on the official HEI website (https://zno.osvita.ua/). Tests designed for B2 level students were used for English language testing. The program and other requirements are available on the website https://testportal.gov.ua/progeng/. The maximum number of scored points is 200 for each academic subject. This sample size is consistent with pedagogical research's principles of validity and reliability. Cronbach's coefficient was used to test the reliability of the instruments used. After the final testing, the students of the experimental group were interviewed by the method of qualitative interviews regarding their opinion about participation in the study.

3.2. Sample

The first-year students of the above-mentioned majors and universities were divided into two groups (one from each university): control and experimental. There was a total of four academic groups. Two were randomly assigned to the control group and the experimental group. Students of the control group studied according to the traditional method as shown in Table 1. Most students in the experimental group had Android-based mobile devices: Android – 34 students, iOS – 23 students. The full-time students' age at the beginning of the research was 17-20 years.

Table 1. Population of the experiment

No	HEI	Control group	Experimental group
1	Luhansk Taras Shevchenko National University	31	28
2	Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University	27	29
	Total	58	57

The sample size was determined according to the number of students that were available for involvement in the research (number of first year students majoring in 014.01 secondary education at both Luhansk Taras Shevchenko National University and Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University). The sample size was determined using expert analysis (considering the possibility of qualitatively implementing the developed model of intensive use of generative strategies, which would be impossible to do qualitatively on large samples). The sample was also tested using the standard population standard deviation and sample standard deviation. It applied Calculator.net service (option to find out the sample size according to confidence level 95%, margin of error 5%, population proportion 50% and population size of the average number of students of the specialty 014 Ukrainian language and literature. English according to the results of the 2021 admission campaign). Given the obtained data in all three ways, the current study's sample is valid.

To avoid errors that could affect the reliability of the results, students of the control and experimental groups were tested on a computer using the same procedure algorithm and the questions' content. So, only the method of preparing students for the final test was excellent. Validity is supported by the pretest data, which showed that the most significant difference between the two groups was only 3%, in favor of the control group. Therefore, the initial average level of success of the control and experimental groups was approximately the same.

3.3. Method

The following methods were used to implement the research: i) Studying the previous experience of using MLT-based GLS using the method of note-taking and creating concept maps; ii) The round table method for discussing and developing a strategy for the implementation of MLT-based GLS; iii) Monitoring method; iv) Computer testing method for evaluating the final study results; v) Methods of statistical processing of data (using Microsoft Excel tools); and vi) The method of qualitative interviews with the simultaneous use of computer-assisted personal interviews (CAPI). There were three mandatory questions to students: “Rate the effectiveness of MLT-based GLS for learning Ukrainian/English on a scale from 1 to 10”; “Which of the GLS is the most effective, in your opinion? (choose from the list presented in Table 1)”; “Name three advantages and three problems of using mobile technologies for education.” Other questions were asked as necessary to clarify the outlined three mandatory ones).

4. RESULTS AND DISCUSSION

The results of the students taking the test in an external independent assessment format were analyzed and summarized to determine the level of previous performance of the research participants. The result is indicated in the relevant external examination certificate, which students submitted when entering a higher education institution. Such manipulations were necessary to reject that part of the points within the 200-rating attributed to Ukrainian Literature. Table 2 and Table 3 present the data on the systematization of students’ academic performance at the beginning of their studies.

Table 2. Results of students taking the test in the format of external independent assessment

	Control group Score range (max.200)	Experimental group Score range (max.200)
Foreign Language	117–196	114–199
Ukrainian Language	123–199	119–197

Table 3. Systematized data on the previous students’ performance

	Average score	Performance percentage	Average score	Performance percentage
Foreign Language	159.7	79.9%	153.8	76.9%
Ukrainian Language	163.2	81.6%	161.9	81.0%

There is no significant difference between the average initial performance of students of the control and experimental groups. The difference was 3.0% in the Foreign Language, and only 0.6% in the Ukrainian Language. The experimental course was followed by a final test to determine the level of knowledge in Practical Ukrainian Language Course and Practical English Language Course. After completing the test, the results of correct or incorrect completion of all closed-ended test items immediately appeared on the screens. Items 1-39 were checked automatically for the Ukrainian Language. The collected test points were converted into a rating of 200. Table 4 presents data on the systematization of students' academic performance at the end of their studies. The results of the final test showed an improved performance in both groups. In the separate section of the data for each student, there was at least a slight improvement compared to the official results of the external independent assessment as shown in Table 4 and Table 5.

Table 4. Results of the final test

	Control group Score range (max.200)	Experimental group Score range (max.200)
Foreign Language	132–199	136–199
Ukrainian Language	133–199	140–200

Table 5. Systematized data on students' performance at the stage of final testing

	Average score	Performance percentage	Average score	Performance percentage
Foreign Language	168.8	84.4%	171.2	85.6%
Ukrainian Language	176.3	88.2%	175.7	87.3%

Comparative Table 6 and Table 7 show that the growth rates in the experimental group are higher than in the control group. This is the main evidence in favor of the effectiveness of using MLT-based GLS to improve the results of students' learning. As a result of the answers to the question "Rate the effectiveness of MLT-based GLS for learning Ukrainian/English on a scale from 1 to 10", the average result was 7.8%. The following effectiveness rating was obtained based on the question, "Which of the GLS is the most effective, in your opinion?" as shown in Figure 1.

Table 6. Result of the increase in student performance before and after the experiment

	Control group Score range (max.200)	Experimental group Score range (max.200)
Foreign Language	+15 – +3	+22 – +0
Ukrainian Language	+10 – +0	+21 – +1

Table 7. Dynamics of performance (comparison of the results of the previous level and final testing)

	Average score	Performance percentage	Average score	Performance percentage
Foreign Language	+9.1	+4.5%	+17.4	+8.7%
Ukrainian Language	+13.1	+6.6%	+13.8	+6.9%

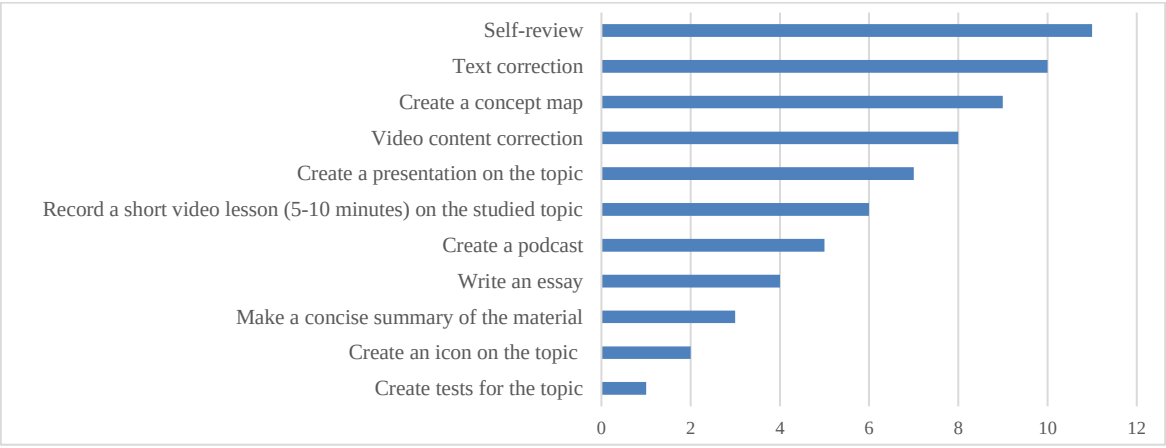

Figure 1. The effectiveness rating of the GLS used in the study

So, according to the students interviewed in the experimental group, the three most effective generative methods for studying philological subjects are self-review, text correction, and creating concept maps. Furthermore, the students faced the task of summarizing their own experience of using MLT. Figure 2 shows the rating of the advantages and disadvantages of using MLT to implement applied GLS noted by the respondents. The percentage of respondents noted the specified advantages or disadvantages is also indicated as presented in Figure 2.

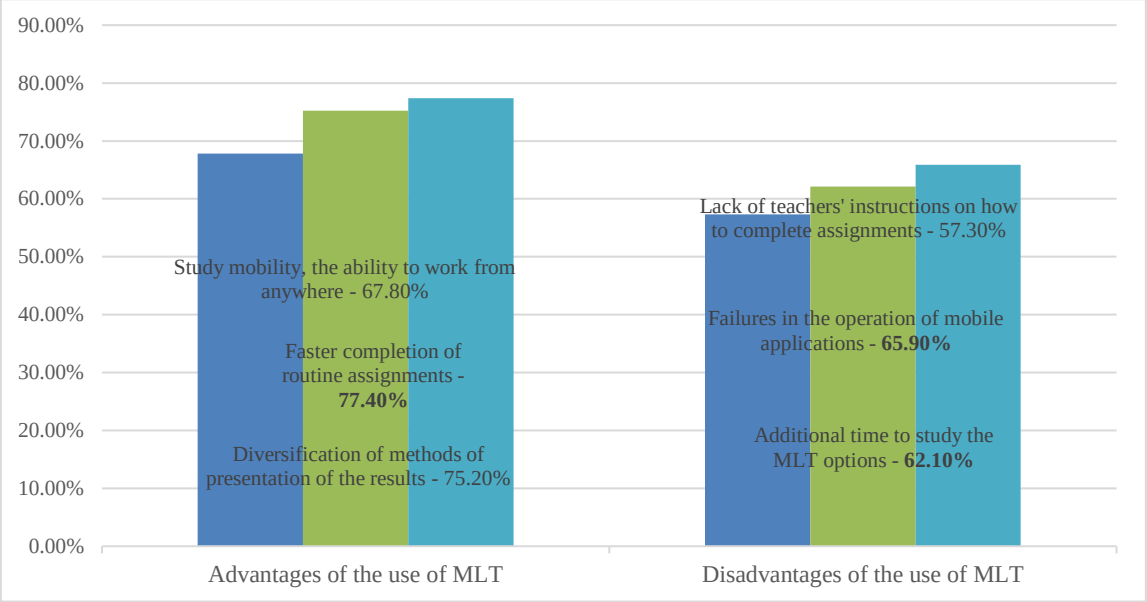

Figure 2. Rating of advantages and disadvantages of using MLT

The empirical data we gathered from this study unequivocally support the conclusion that integrating MLT into game-based learning systems (GLS) is a highly effective approach within the context of higher education. In particular, an empirical study [8] found no significant differences between the note-taking and read-only groups on the comprehension or memory tests. A previous study [9] also noted the effectiveness of the graphic organizer GLS. Our research based on qualitative interviews and their results (Figure 1) also notes the effectiveness of such methods, particularly in creating concept maps.

The data on the uneven effectiveness of using different generative methods also corresponds to the previous study [1]. Here, attention is also paid to effectiveness for different age groups. This point was omitted in the current study because all students were approximately the same age group. The adequacy of the use of mobile technologies specifically for modern students and the next generations of higher education students should also be noted [31]–[33], because these are precisely the representatives of generation Zet (colloquially known as “Zumers”). This refers to people born between the second half of the nineties and the second half of the 2000s (1996-2010). Generation Z is precisely characterized by using Internet resources, mobile phones, smartphones (according to the definition of “Digital Native”). However, the need for additional training and stimulation of teachers (as representatives of older generations) to more intensively implement mobile technologies [34] to optimize the educational process in higher education [22], [35] should also be noted. Additional teacher training on the methodology of using mobile technologies in the higher education environment is also appropriate [36].

The simultaneous use of GLS and MLT was productive, extending the findings of a previous study by Kim [24]. The study found positive student perceptions and overall satisfaction with their experience using mobile technologies while teaching a professional English course for medical students. In particular, Chan [26] noted the effectiveness of mobile technologies in teaching students to write and read. Instead, this study confirms the strengthening of the effect of using GLS combined with MLT. However, this aspect needs additional contrast testing. For example, a control group will learn using GLS only, and another will learn using MLT-based GLS. The study allowed us to draw practical conclusions useful for educational institutions and teachers. In particular, the results confirmed that using MLT in combination with game-based learning systems (GBLS) is an effective approach in higher education.

The theoretical contribution consists of summarizing the latest research on the topic, and explaining the meaning of the terms "generative strategies" and "mobile technologies." The understanding of the content of these concepts is deepened, and it shows how they are implemented in the conditions of the real educational process. The practical contribution of the study consists of empirically proven successful experience of using generative strategies based on mobile technologies to stimulate students' academic success. It was also possible to get feedback from students regarding participation in the experiment, where most of them rated the effectiveness of generative strategies based on mobile technologies for learning Ukrainian/English at the level of 7.8 out of 10, quite positively. The methodological contribution of this study is that a comprehensive, harmonious and reproducible model for applying generative strategies based on mobile technologies has been developed and tested in other possible studies. More and less successful techniques of applying generative strategies are determined. The strengths and weaknesses of the approach to educating specialty 014 secondary education students have been identified.

5. CONCLUSION

The modern paradigm of higher education is aimed primarily at teaching students who are representatives of Generation Z, and in the near future-Generation Alpha. Both of these generations are united by the inclination and naturalness to use computer and information technologies in everyday life and other activities. For these generations, interacting with a smartphone is as natural as reading paper magazines or watching television for older generations.

The effectiveness of MLT-based GLS in higher education is confirmed by the comparative performance results obtained through computer-assisted testing in Practical Ukrainian Language Course and Practical English Language Course. So, the experimental group's results showed an increased performance in English Language by +8.7%, and in Ukrainian Language by +6.3% within the group. As some students worked with Android-based mobile devices (34 students) and others with iOS (23 students), this could affect their final results. This study did not consider that some smartphones had more powerful processors and more memory, which contributed to ease of use and could affect overall learning effectiveness. For example, there were often cases when technical failures in the operation of mobile applications prevented the teacher from fully completing the given task.

The research results can be used in theoretical studies about modern approaches to organization of the educational process in HEIs. It is also advisable to consider the proven effectiveness of using MLT-based GLS and the scheme of implementing these approaches proposed in Table 1 during the educational programs for higher school students.

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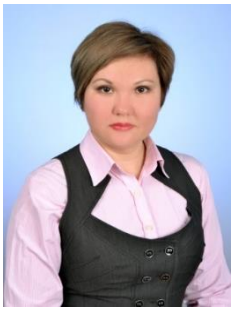

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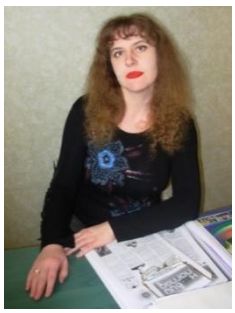

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