

Constructivist pedagogy in E-learning: Solving problems of interaction with a student

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Abstract

The study focuses on improving e-learning effectiveness and its implementation during the COVID-19-induced lockdown. The study involved 328 students aged 20 to 24 years with an equal number of males and females. Research shows that e-learning is mostly used together with embedded pedagogical tools and technologies rather than single training programs to improve the quality of teaching based on a unified method. Constructivism is an effective approach for this purpose. The research results can be used in programs with embedded learning elements based on constructivist pedagogy in online and blended learning at higher educational institutions.

Keywords: e-learning; constructivism; student-teacher interaction; problem-based learning; student-centered learning; individual learning path

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1. Introduction

1.1. Conceptual or theoretical framework

Modern education faces two challenges that define its future development. First, the virtualization of learning and transferring learning processes to the digital environment. Second, the need for students to form their individual learning paths and learning models (Aboagye et al., 2021). Several researchers have suggested that COVID-19 has only accelerated processes that were moving toward total virtualization and digitalization before (Aboagye et al., 2021; Batubara, 2021).

The methodology and philosophy of constructivism emerged predominantly in the United States as a response to the inability of the prevailing behaviorist methodology of schooling to cope with the 21st century skill formation challenges required in a world built on a digital environment and the constant accumulation of knowledge (Luo et al., 2017). This ability requires a different approach to the early stages of learning and an independent learning trajectory in higher education (Mustapha, 2017). Constructivist teaching methods and pedagogical tools were predominantly developed based on standard classroom education and in the first stages mainly for school education (Koptseva, 2020). It has become common in developing countries going through processes of adapting their educational systems to the standards and requirements of the 21st century (Hadullo et al., 2018; Goh et al., 2020).

E-learning is actively adopting constructivist approaches to learning, but it faces several challenges (Hadullo et al., 2018; Basuhail, 2019; Kibuku & Ochieng, 2019). Part of the problem is the digital distance between a teacher and a student. This imposes certain additional requirements on the methodology of the lessons and increases the importance of students' independent efforts (Pham et al., 2018; Vlasova et al., 2018; Son, 2019). This also poses the challenge of increasing motivation and building active student engagement in the learning process (Lee et al., 2019; McHaney et al., 2018; Lin et al., 2020).

1.2. Related research

Using constructivist methodology for learning in higher education institutions is considered by academic researchers mainly in several isolated and more or less clearly articulated approaches (Basuhail, 2019; Lin et al., 2020; Kassymova et al., 2020; Paul et al., 2021). As with school-based learning, constructivist methodology has primarily gained traction in physics, mathematics, and other natural sciences (Vitoria et al., 2018; Siagan et al., 2019; Xia et al., 2019). However, there are many studies that apply these same methods of learning and shaping a student's independent worldview and personal learning trajectory for humanities majors (Xu & Shi, 2018).

The impact of virtualization of learning on a learner raises a few significant problems, among which the increase of anxiety, the drop in motivation for own development and completing the learning course, significantly more distractions, and the lack of effective control by an instructor stand out (Li et al., 2017). The remoteness of a student and the lack of face-to-face interaction online creates the effect of "digital distance", which reduces education effectiveness and creates a need for communication and the personal presence of an instructor (Korucu & Cakir, 2018). Meanwhile, it is e-learning that provides significantly more opportunities in shaping an individualized learning trajectory, allowing for more freedom in allocating time for learning or other activities (Asamoah & Oheneba-Sakyi, 2017; Lee et al., 2019). E-learning plays a defining role in lifelong learning and knowledge updating as well as professional development (Basuhail, 2019).

The fact that most children grow up in an increasingly complex digital environment requires developing appropriate skills to use this environment as an effective learning environment (Aboagye

et al., 2021; Kibuku & Ochieng, 2019). A constructivist philosophy of education can act as a solid foundation for students to develop the skill of independent knowledge modeling and its effective application from an early stage of learning (Asamoah & Oheneba-Sakyi, 2017). Current research points to gaps and challenges in the practice of remote, electronic, mobile, and blended learning highlighted clearly by the COVID-19 pandemic (Aboagye et al., 2021). Nevertheless, virtually no academic work has investigated the specifics of enhancing the effectiveness of a real-world type of learning in which teachers use embedded elements and methods of certain pedagogical technologies rather than whole programs (Siagan et al., 2019; Ştefan, 2017). The constant development of technology and pedagogy will bring the education system of any country, especially a developing one, into a state of permanent transformation and reform (Ichaba, 2020). Most teaching techniques will be embedded techniques based on some general educational philosophy, a role that many researchers now believe is best suited to constructivism (Asamoah & Oheneba-Sakyi, 2017).

1.3. Purpose of the study

For the study, two null hypotheses were formed. The first null hypothesis: there is no statistically significant difference in objective assessment of students whose e-learning includes or does not include constructivist pedagogy elements, techniques, and methods. The second null hypothesis: there is also no statistically significant difference in students' evaluations of the most significant e-learning parameters for the groups using and not using constructivist approaches to learning.

2. Methods and materials

2.1. Research model

The study uses an experimental study model with a quantitative analysis to compare pre- and post-test results to determine the outcome of the experimental intervention. A representative sample of participants is used. The study applies the null hypothesis testing method.

2.2. Participants

The study involved 328 second- and third-year university students aged 20-24 years (equal numbers of males and females). Based on the number of university students, the possible statistical error of the sample does not exceed $p = 3.68$.

Thus, the sample can be considered representative and statistically reliable. The sample was formed according to the principle of random selection within the specified age and gender ratio. In the first stage, the sample was drawn randomly from the list of university students. After that, the procedure of acquainting a potential participant with the expected experiment and obtaining his/her consent was conducted. A sample was formed from those who consented to participate in the study according to the specified principles. The study was conducted in the form of individual e-mail surveys.

Second- and third-year students were chosen because according to several existing studies (Kassymova et al., 2020; Korucu & Cakir, 2018; Lee et al., 2019), this category of college and university students already has the necessary initial independent work and search skills. They are familiar with training procedures and algorithms at a higher education institution but are still transitioning to a more independent form of searching and shaping their trajectory of academic learning. Consequently, it is this category of students who are more vulnerable to all the challenges of e-learning (Hussain et al., 2018).

2.3. Data collection tools

The study was conducted in the form of two sets of surveys and an experimental intervention. The first survey was conducted before the intervention and the experiment itself, as an assessment of existing problems in the interaction of students with each other and with an instructor during e-learning. This survey was conducted on remote learning material during the lockdown period of the COVID-19, when the entire learning process moved to a remote environment. This survey was conducted in two stages. In the first stage, students were asked to define the most significant problems they encountered during e-learning at the lockdown time in one short sentence. The researchers then analyzed, grouped, and reworded the collected formulations as concisely as possible (see Figure 1). The reformulated wording was then offered again to the interviewees for approval and correction. This process continued until all participants were in full agreement with the wording of the most significant problems in the survey. After agreement was reached on the wording, the survey itself was conducted.

2.4. Data collection process

Participants were divided into two groups: an experimental group (group 1) and a control group (group 2) with equal numbers of participants and equal gender and age composition (Table 1). The control group continued e-learning with the same program and methods that had been developed before based on the university program during COVID-19. The experimental group received training introducing methods and tools of constructivist pedagogy (described in more detail later in the Intervention section). The training continued for 2 months within the same university program.

Table 1. Distribution of the sample by gender, age, and university grades

	male				female					
	age 20	age 21	age 22	age 23	age 24	age 20	age 21	age 22	age 23	age 24
2nd grade	19	18	18	16	11	19	18	18	16	11
3rd grade	18	18	18	16	12	18	18	18	16	12

At the end of the two-month experiment, the participants were offered tests on the educational material they had studied. The tests were not specifically designed by the researchers. To preserve the experiment evaluation objectivity in the situation with real-world pedagogical tasks, the standard university tests for this major were used. The assessment was based on a 12-point scoring system. Thereby, objective results of academic performance evaluation were obtained in both groups.

At the end of the experiment, participants also ranked on a 5-point Likert scale the four most significant categories, providing a subjective assessment of the learning quality: comfort, level of engagement in the learning process, motivation to complete and continue learning, and confidence (as the opposite of academic anxiety). This set of parameters was determined by the researchers for this survey based on the evaluation and comparison of the results of numerous empirical studies on the subjective state of college and university students during remote learning, e-learning, and MOOCs (Asamoah & Oheneba-Sakyi, 2017; Hadullo et al., 2018; Hooda & Rathee, 2018). These are the parameters most used by researchers to assess the effectiveness of student interaction in e-learning.

2.5. Intervention

A variety of teaching methods and techniques based on the constructivist approach and educational methodology were used in the teaching process for the experimental group. Each of the

teachers involved in the work with the experimental group was free to choose specific teaching methods and techniques, with the only requirement to use predominantly constructivist teaching methodology (over 60% of the teaching material and tasks for this group had to be constructivist approaches). All the teachers who took part in the experiment had relevant knowledge and used constructivist teaching methods for at least 5 years in university practice, which was a prerequisite for their participation in the experiment.

The teachers mostly used problem-based learning method and collaborative learning techniques based on the interaction between students in a digital environment with the help of the Internet and mobile devices. Students had to use cloud services and social networks to communicate with each other, exchange opinions and solutions, develop collaborations, and share responsibilities in researching a task and finding a solution. Forms of collaboration were not specified and were left to the participants' discretion. Teachers acted as tutors and mentors, provided tips and directions for finding a solution and information sources.

In the problem-based learning approach, 42% of all assignments included individualized tasks and focused on the specific features and an emerging individual learning trajectory of a particular student according to a teacher's understanding. Teaching was based on assignments aimed to help a student form a clear idea of the essence of the studied material and methods of working with it. Each assignment led a student to the next step of understanding the general university program of a discipline.

Along with these methods, the usual standardized teaching methods were used, such as lectures, the provision of electronic teaching materials and textbooks, the distribution, testing, and discussion of assignments online, and the provision of reading lists for students to master the literature on their own. The organization and division of the learning process between traditional forms of teaching and constructivist methods was left to the discretion of a particular teacher. Thus, the intervention largely mimicked not the ideal form of constructivist learning, but the real situation as it unfolds in most learning institutions around the world as a result of lockdown and the mass transition to remote forms of learning in a digital environment. In all these teaching methods, the traditional curriculum of a particular educational institution is mixed with the modernized innovative forms of teaching, which are expected to produce better results.

2.6. Data analysis

The results of an objective evaluation of participants' academic performance, as well as the results of surveys and subjective evaluation of problems before and after the intervention, were investigated by methods of descriptive statistics. The relevant data are presented below. The hypothesis of the study was tested using Student's t-criterion on the mean values of the samples obtained in the experimental and control groups. The authors compared the results of the objective knowledge test and students' assessments of e-learning problems (primary test). The aim of the study using Student's t-test was to identify the presence or absence of statistically significant differences in the assessments of the two groups.

2.7. Statistical processing

SPSS 22.0 software package was used for statistical research. MS Excel 2019 was used to visualize the results of the study.

2.8. Ethical issues

The study was conducted anonymously and with the participants' consent. The conditions and rules of the experiment were explained to the participants, except for the points that could influence their attitudes and lead to a bias in their scores during the survey. All surveys were conducted using individual randomly generated email addresses, ensuring that all participants were uniquely identifiable and yet completely anonymous, and no personal data could be recorded. No personal data of participants were collected, stored, or used during the research process.

2.9. Research limitations

The study was conducted for a limited age group of students and the results may differ for undergraduate, college, or high school students with other cognitive and social behaviors. Moreover, a broad set of constructivist pedagogies was used rather than a strictly typified approach using one teaching methodology based on constructivist theory. This approach also limits the generalization of the results.

3. Results

Figure 1 presents the results of the survey on the most significant problems that students encountered when studying online. Students mentioned difficulties in their interactions with a teacher and with each other. Technical difficulties include all forms of disruption to the network, software, or electronic devices that are supposed to support the learning process. Academic anxiety is the experience of insecurity in one's knowledge, anticipation of grades, fear of academic failure, and a group of other experiences that in the academic literature have received the above terminology definition (Hasty et al., 2021). Lack of control implies a lack of proper supervision of a student's work by a teacher, a delay in checking assignments and reporting results, etc. Weakening of motivation means both a decrease in motivation to learn and a decrease in motivation to complete current assignments, participate in lectures, and finish the course.

Cognitive difficulty is a category that summarizes lack of understanding of the material being studied, difficulty in finishing an instructor's assignments, misunderstanding of terminology and a teacher's explanations, etc. Misunderstanding with a teacher is a category that includes all forms of relationship problems of an emotional or behavioral and cognitive nature. Notably, when defining problems, none of the participants mentioned or articulated problems related to students' communication with one another.

When researchers inquired about the reason for this assessment, participants pointed out that communication between students was carried out during the lockdown through informal channels. Learning collaborations, joint exercises, and other similar forms of interaction in the virtual classroom were not practiced. At the same time, the students interacted with each other informally to promote learning and achieve higher academic grades. Students also noted that they provided moral support and motivation to each other and often approached each other with relevant problems for help.

Student assessments of existing problems in the interaction of students with each other and with a teacher during e-learning

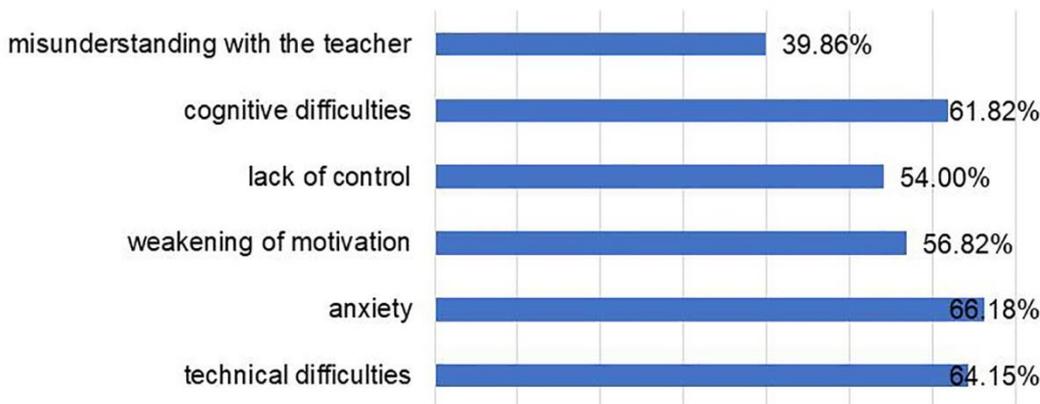


Figure 1. Student assessments of existing problems in the interaction of students with each other and with a teacher during e-learning

Figure 1 shows the percentage of respondents for whom a problem was pressing and had a significant impact on learning. The least pressing problem was the problem of interaction with teachers and the emotional and psychological problems encountered (it was mentioned just by 39.86% of the participants). This means that 4 out of 10 students felt emotional discomfort from some form of communication with an instructor during online learning, which is a very pressing issue. The most significant difficulties were cognitive and technical (61.82% and 64.15%). It is the presence of significant problems in mastering and understanding the material in independent assimilation and analysis that demonstrates the need to involve the principles of constructivist pedagogy in the process of e-learning, especially with its mass introduction in universities and schools. The technical challenges and unpreparedness of pedagogy for total remote learning are beyond the scope of this study, but these difficulties have been reported by researchers all over the world (Kibuku & Ochieng, 2019; Koloszár & Zsolt, 2020; Korucu & Cakir, 2018; Maré & Mutezo, 2020).

Approx. 66.18% of respondents suffered from anxiety in various forms, which is also characteristic of the lack of constant personal contact, support, and control from a teacher. Such a high percentage for this category of problems should be expected. Over half of all participants experienced difficulties due to the lack of constant supervision from a teacher, which they were used to in the classroom teaching system or in blended learning (54%). Weakening of learning motivation is also a widespread and universally noted problem of e-learning (56.82% of respondents). Constructivist methodology of learning assumes deep involvement of learners in forming their own model of knowledge, which provides a much higher autonomy for a learner and, at the same time, has a teacher as a mentor whom one can ask for advice. For e-learning, this is a more organizationally acceptable approach than the traditional iteration of lectures and assignments followed by testing.

The intervention with constructivist pedagogy methods was designed to cope precisely with the problems identified in the survey above. There is a direct correspondence between the main significant parameters of e-learning, which many empirical studies point to, and the problems

identified in the first survey. In most countries of the world, the problems of transition to e-learning and different forms of remote learning have similar characteristics.

Participants' evaluation of the main e-learning parameters based on the experimental intervention results is presented in Figure 2. For all the examined parameters, experimental group participants scored significantly higher than control group participants, in which the constructivist learning approach was not used. The results of comparing the scores for each of the criteria using Student's t-test are presented in Table 2.

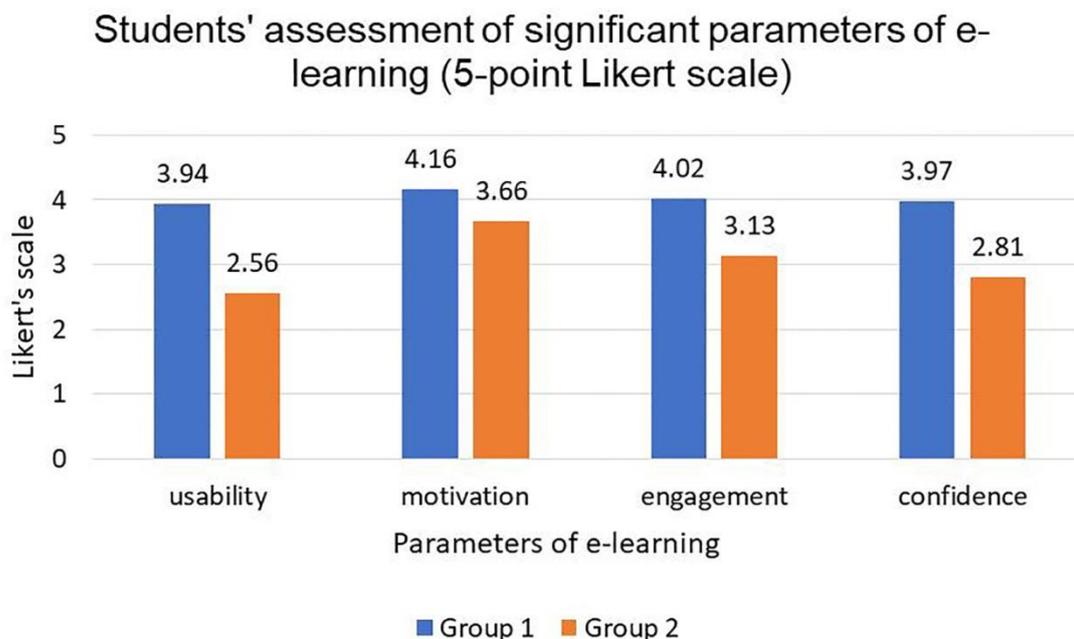


Figure 2. Students' assessment of significant e-learning parameters (5-point Likert scale)

The differences between the assessments reported by the participants of the experimental and control groups for each of the parameters relevant for e-learning are statistically significant and are not determined by random factors. Thus, students' subjective assessment indicates greater effectiveness of the constructivist pedagogical approach in maintaining students' self-confidence (3.97 in the experimental vs. 2.81 in the control group) and high motivation (4.16 vs. 3.66, respectively). The most highly rated parameter turns out to be the usability of e-learning with the constructivist approach (3.94 and 2.56, respectively). This is the most significant difference in assessments. Engagement of experimental group students also turned out to be higher, but not so significantly (4.02 vs. 3.66 in the control group), which indicates, according to the authors, the efforts of university teachers and the fact that they considered the lockdown experience during the COVID-19.

Table 2. T-test results for Students' assessment of significant e-learning parameters

	usability	motivation	engagement	confidence
<i>p</i>	.32	.41	.28	.26

The results of the objective assessment of knowledge also confirm the result obtained earlier as subjective evaluations of students. In general, the results of experimental group students were significantly higher than the results of the control group (Figure 3). None of the students received

grades below 5. For a more convenient presentation of the data, students were divided into groups according to the score received to demonstrate the dynamics of the distribution of grades as a percentage. Statistical evaluation of both groups using the Student's t-test was conducted without dividing them into subgroups according to individual grades, because it makes little sense. Here this division is carried out only for the visual orientation of a reader on the graph. According to the test results, $p > 0.05$, which leads to the conclusion that the difference in the academic performance of the experimental and control groups is statistically significant and not random.

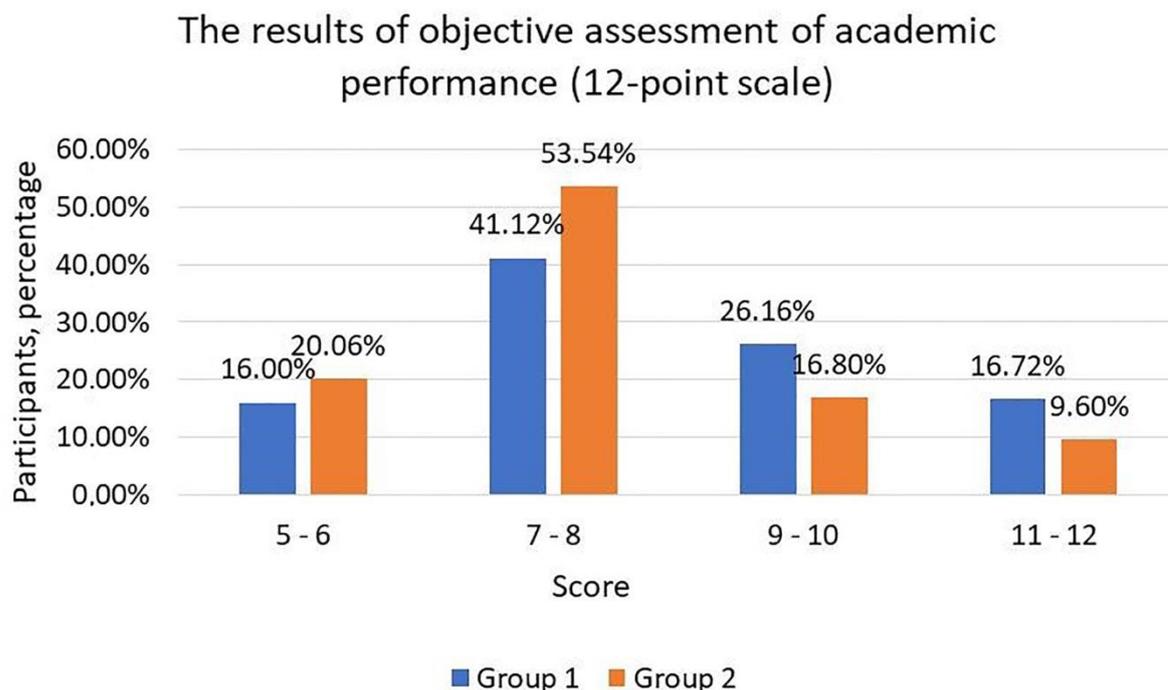


Figure 3. The results of objective assessment of academic performance by standard university test (12-point scale)

Thus, based on the subjective evaluation of e-learning significant parameters by students and the objective evaluation of their academic results, the null hypothesis of the study should be discarded. It should be noted that in terms of academic achievement in the experimental group, the number of students who received higher grades (26.15% received 9-10 points and 16.72% received 11-12 points, compared to 16.80% and 9.60% respectively in the control group) increased because of the influence of constructivist approaches to learning. Respectively, the relative proportion of those with lower scores in the experimental group decreased: 16% and 41.52% in the control group versus 20.06% and 53.54% in the experimental group (Figure 3).

4. Discussion

Empirical research on constructivist methodology in colleges, universities, and schools has been actively pursued over the past decade throughout almost the entire world (Asamoah & Oheneba-Sakyi, 2017; Hooda & Rathee, 2018; Koptseva, 2020; Korucu & Cakir, 2018). This methodology is particularly important in developing countries, for which the most important educational objectives are fostering self-learning skills, promoting learning throughout one's career, and training as many professionals who are ready to solve real-world problems as possible (Lin et al., 2020; Li et al., 2017;

Maré & Mutezo, 2020). However, researchers have prioritized the study of specific methods or applications of constructivism as an educational philosophy. These are primarily problem-based learning or student-centered learning (Aboagye et al., 2021; Hassan et al., 2019; Korucu & Cakir, 2018; Lee et al., 2019).

Significant improvements in academic achievement and critical thinking skills have been noted by most researchers in relation to the use of constructivist methodological approaches (Maré & Mutezo, 2020; Masaviru, 2020; Xia et al., 2019). New curricula in all subjects are actively being developed, with a greater emphasis on science, physics, and mathematics (Masaviru, 2020; Siagan et al., 2019; Vitoria et al., 2018; Xia et al., 2019). Arguably, the constructivist methodology itself has historically been more focused on teaching mathematics; it has been shaped by this empirical base (Asamoah & Oheneba-Sakyi, 2017; Koptseva, 2020). Nevertheless, the results obtained in this study are consistent with those of other researchers in several countries regarding the application of constructivist methodology and its learning tools in the humanities (Kibuku & Ochieng, 2019; Koloszár & Zsolt, 2020; Korucu & Cakir, 2018).

Teacher training plays the greatest role in the qualitative application of constructivist methodology, as noted in several studies (Goh et al., 2020; Hooda & Rathee, 2018). Researchers have expressed the belief that the lack of this stance and teacher unpreparedness make the use of constructivism simply not possible in the classroom (Miller-First & Ballard, 2017). Teachers' training and their own preparation for the deeper subject matter vision necessary to engage and guide students and learners remains beyond the scope of this study but has been scrutinized by other researchers (Hussain et al., 2018; Lee et al., 2019; Lin et al., 2020; McHaney et al., 2018).

So far, the authors have been unable to find studies that have empirically examined the constructivist approach in terms of elements, tools, and techniques used by educators not as part of a specific program or instructional approach like problem-based learning, but as an embedded part of a regular curriculum. The literature repeatedly describes studies demonstrating the much higher effectiveness of constructivist learning tools, individual approaches, and programs (Paul et al., 2021; Ştefan, 2017; Xu & Shi, 2018). Real-world problems with e-learning have been described by works that highlight educators' confusion, especially during lockdown, and their lack of willingness to apply deployed and trained e-learning-oriented programs (Batubara, 2021). Actual experience shows that it is the built-in mechanisms of a constructivist approach to e-learning that is consistent with what educators around the world are trying to do to improve the teaching of their subjects (Sarker et al., 2019; Siagan et al., 2019; Vitoria et al., 2018). At the same time, it is the motivation and engagement of students who suffer from cognitive and psychological problems in e-learning that is crucial (Hussain et al., 2018).

5. Conclusion

Digitalization and virtualization of learning require the development of skills that can help students to form a knowledge system and create individual learning trajectories. Constructivism is an effective and widely used methodology around the world to achieve these goals. This study focuses on improving the effectiveness of e-learning and eliminating its identified problems by applying constructivist methodology. The novelty of the study is the focus on the embedded pedagogical methods and technologies rather than on the integral training programs used in most e-learning programs. The aim of the study was to test whether the academic performance and personal experience of the online learning in second- and third-year students would change in a statistically significant way when using a constructivist approach to learning. The study involved an equal number

of men and women aged 20-24 years from the respective university courses (328 people). They formed equal experimental and control groups. Both groups received e-learning, but the experimental group used the approaches and methods of the constructivist pedagogical methodology. An unstructured free survey was conducted to identify the most significant problems encountered in e-learning. Based on the results, intervention features were selected with the help of teachers familiar with the constructivist pedagogy tools and methods. After 2 months of e-learning, a survey was conducted to assess the most significant parameters of e-learning and an objective test to assess knowledge. The results of both tests were compared using Student's t-criterion. The results showed a statistically significant difference of higher academic results and high assessment of learning by experimental group representatives. Further research can focus on the specifics of using constructivist methodology in e-learning for undergraduate students continuing their education and school students, considering the peculiarities and features of these groups.

6. Recommendations

The authors recommend the widespread use of various constructivist pedagogical approaches in the practice of online learning for university students. Teachers are also encouraged to determine their own approaches and specific methods in accordance with the characteristics of a study group and other conditions.

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