



Assessment of academic achievements in m-learning

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Abstract

The paper analyzes the teaching experiment regarding the use of mobile apps in the assessment of student learning. The study involved survey and self-description methods offered to students and instructors to assess the effectiveness of using mobile apps in learning. The study was conducted among 320 s-year students of the I.M. Sechenov First Moscow State Medical University and 8 instructors between September 1 and December 28, 2021, during the academic semester. Socrative and Plickers apps have been found to contribute to: better learning ($\varphi^* = 8.94$, $p \leq 0.01$); developing cognitive motivation among students resulting from diverse learning resources used with apps ($\varphi^* = 7.6$, $p \leq 0.01$); convenience of learning activities because students can work with the app both in the classroom and at home ($\varphi^* = 13.66$, $p \leq 0.01$); improved digital competence ($\varphi^* = 2.4$, $p \leq 0.05$). The research findings can be used by instructors in universities and secondary schools. Since didactic opportunities offered by mobile apps are quite significant, and considering other positive results of their use, this technology may be considered as an important tool for training young people and strengthening their cognitive motivation.

Keywords Advantages and difficulties of using mobile apps for learning · Assessment of learning achievements · Didactic opportunities offered by mobile apps · Mobile app · Student–teacher interaction

1 Introduction

In recent years, the technological revolution has changed the way people perceive and interact with reality. Inevitably, education and didactic planning also had to deal with new technologies—special mobile apps (Socrative and Plickers), online learning programs (Moodle, ATutor, Eliademy, etc.), cloud services, and creation of

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shared documents (Bile, 2022). Indeed, digital tools have radically changed people's lives since childhood, especially when it comes to Generation Z, born since the early 2000s.

At the moment, many educational technologies that have been tried for years have lost their relevance due to the significant gap between educational technologies and the students' lifestyles (Bile, 2022). The point is that traditional educational technologies (general questioning, question–answer interactions, etc.) no longer secure significant learning achievements, because students are increasingly living and interact online (Cladis, 2020). For them, being online has become habitual and mainstream—i.e. the standard satisfying their needs. Yet, the academic program that does not allow such technologies cannot provide a sufficient learning motivation for students. Traditional technologies and techniques are perceived by students as irrelevant, boring, outdated (Dennen et al., 2020). Therefore, ensuring effective learning and a significant motivation of students becomes possible only with information technology (e.g., Moodle online learning system, setting up meetings and conferences in Zoom, using Socrative and Plickers learning apps, etc.) in the learning process. Mobile apps are especially relevant because interactions via smartphones are common and comfortable for students (Eynon, 2021). That is, the use of mobile apps in the learning process is essential for strengthening the students' cognitive skills. The point is that in the case of traditional classroom learning, the student is not in the familiar virtual reality environment. By using the smartphone for learning purposes, students find themselves in the familiar virtual reality environment, which becomes an important tool for learning rather than a means of pastime and distraction from the learning process. Therefore, by using mobile apps and other technology, the student takes a cognitive interest immediately in learning the program, and then the course content.

Many innovative educational institutions use information technology to accelerate learning and improve its focus. Typically, information technology can be used in two ways in higher education: to expand digital competence (from creating Power Point slides to multiple factor analysis in SPSS for Windows or working in Socrative and Plickers mobile apps); and to develop niche competence—for example, the use of SPSS for Windows by marketing or sociology students as the primary tool for working with arrays (Khan & Markauskaite, 2017).

The relevance of mobile apps in the learning process is a modern challenge, attempts to deal with which are discussed worldwide (Pedro et al., 2018). Development of information technology has established new requirements and conditions for the implementation of learning at various levels. For example, in 2020, due to COVID-19, many students were forced to quickly switch from classroom instruction to online learning, make purchases and obtain services (e.g., banking) online, let alone the fact that most class assignments are performed by students using technology rather than stationary as before. Such issues are discussed in a number of studies. For example, attention has been paid to the issue of using information technology in adolescents' learning and developing their competence with e-texts (Kiili et al., 2022). This study examines how high school students evaluate the credibility of e-texts in terms of four main aspects of credibility: author's experience, author's intent, publishing practices of venue, and quality of evidence. Furthermore, the

paper explored how students' prior knowledge of the topic, beliefs about Internet-specific epistemological rationales, and behavioral engagement were related to students' rationales for trusting the e-texts with which they worked. Attention is also paid to the relevance of information technology and digital tools among online learners in Spain (Arrosagaray et al., 2019). This paper provides a comprehensive study of students' attitudes toward information technology in the learning process when comparing the frequency of using digital tools in the classroom and at home. Almost half of students in Spain hardly ever use online learning technologies or do it very rarely (a few times a week). Students mentioned that, quite importantly, online learning technologies, especially when working in small groups (for example, at online conferences), make learning more effective, with students being able to understand the course content and memorize it for future use in learning and professional activities. The researchers also argued for the importance of introducing technological competence in the learning process, thus contributing to other professional competences: processing learning resources, working with primary sources, set up of teamwork, highlighting the most essential aspects in the learning resources, presenting own position, upon completion of the research, as image and video files, etc. (Bergdahl et al., 2020). Computer-assisted learning was more successful in learning the social and natural sciences, with less success in creative classes and economics. The need to integrate information technology into the school's culture and university education is also a pressing challenge (Blau & Shamir-Inbal, 2017), which reveals to the global community a number of methodological problems in the implementation of this task. For example, choosing exactly those programs and apps that will be most convenient and effective for the learning process, ensuring the training required from students and instructors to work with technology, the most effective combination of classroom work and online learning. Implementation of information technology and mobile apps in the learning process at elementary schools and among adolescents, for example in Brazil, is an important problem (Cabello-Hutt et al., 2018) and Spain (Gil-Flores et al., 2017). A study conducted among Brazilian students revealed that teenagers use the Internet and technology most often in education, compared to younger students (Cabello-Hutt et al., 2018). Another important thing pertaining to this study is that it provides data on technology and internet use by children and adults, as this paper focuses on both student and instructor competence in mobile apps used in learning. A Brazil case study revealed that many children have surpassed their parents in technology, although they often work on the Internet with them (Cabello-Hutt et al., 2018). Adults act as mediators of this process, identifying the risks that children may encounter online. Also, when working with technology, students developed their digital skills and the ability to learn online. The study conducted among learners in Spain analyzed the characteristic features of the implementation of Teaching and Learning International Study (TALIS), which involved 3,339 instructors (Gil-Flores et al., 2017). The crucial factors for the successful use of TALIS interactive technology include: teaching experience (the more experience, the easier it is for the instructor to introduce technology into education); the need for instructors to develop competence in the use of information and communication technology (identified among 65.6% of respondents); instructor interaction and providing the technology with reporting instructions for use (Gil-Flores

et al., 2017). Therefore, the instructors' ability to use technology in the learning process is affected by both their traits (experience, desire to develop competencies and interaction) and specific features of the technology itself (elaboration of technology and availability of clear instructions).

Especially important is the researchers' task pertaining to the use of mobile apps (such as Socrative and Plickers, flipped classroom) and digital tools in developing creativity, motivation, expression and interactive skills among students, which involves not only the set-up of the learning process, but also the features of students assessment (Cladis, 2020). Recent studies have explored the opportunities offered by interactive technologies to enable group-based learning in educational settings (Cole et al., 2017). These authors used Scoop.it, 1 Case-Based Learning, Campus Pack Wiki, Cardiff blogs and Facebook to set up and implement student teamwork in the learning process. They argued that the use of different technologies leads to different results in the learning process and teamwork. For example, Facebook is well known and popular among students. Links may be posted directly in the feed, with comments made in the thread. It is possible to see who viewed the post, and groups can be created with different privacy settings. Campus Pack Wiki technology is user-friendly for group collaboration assignments on the same document. Edits are available for auditing—it is possible to see who contributed to the task. Additional pages can be added easily. Documents as well as hyperlinks to web pages can be uploaded. Scoop.it's Pinterest Del.icious technology makes it easy to add web-based resources to pages through *bookmarkets* and add comment. Resources can be shared with other social media websites. Groups can contribute to pages with the same topics. Cardiff blogs technology enables publishing articles and comments with links. Post can be commented.

This being the case, the use of technology (Moodle, Campus Pack Wiki, SPSS for Windows, ATutor, Eliademy) and mobile apps (Socrative and Plickers) in the learning process is a global problem in science and education. This problem is very relevant in Russia as well, where learning technology is affected by global trends: use of online learning systems (Moodle, Yo-Stady, ATutor, Eliademy, Dokeos); wide use of social media and the promotion of educational institutions' websites and Facebook; use of GoogleClassroom technology, shared documents, messengers to support the learning process (e.g., Viber groups to share information within the school), etc. (Danilina & Seregina, 2017). The importance of this research problem is explained by insufficient knowledge of the learning opportunities offered by mobile apps in developing students competencies; lack of conventional and well-developed technologies for implementing mobile apps in the learning process, which is addressed in this paper.

The paper discusses the practices of experimental use of mobile apps to assess the effectiveness of students' learning, which will bring the evidence-based clarity to the problem of using learning technologies Russia and other countries.

The value of this research consists not so much in arranging the searches conducted by other authors, but in describing the results of our experiment, identifying the effectiveness of mobile apps in the learning process, the features of their use and the difficulties of their implementation. The research findings have practical implications, as they help to expand the use of mobile apps in the evaluation of

learners' activities and determine the vectors of development of such focus area in the methodology and technology of education. The novelty of the article is to study the possibilities of developing new methods for assessing the academic performance of students during m-learning, which intensified in a pandemic. The novelty also lies in the use of new modern mobile applications in assessing the academic performance of students.

1.1 Literature review

Special aspects of the use of mobile apps in the learning process are addressed in various contemporary studies.

Important research in this area focuses on implementing social media and special programs (Go Iteens, Code Club, Scratch) in the learning process of adolescents (Dennen et al., 2020). The use of mobile apps (e.g., Socrative and Plickers) and a variety of digital tools (Moodle, Campus Pack Wiki, SPSS for Windows, ATutor, Eliademy) are studied in the context of the implementation of various tasks and learning different subjects—students' competence in self-assessment of cognitive activities. Informative research on the interaction of digital skills and English language proficiency among Arab students was conducted, which involved a comprehensive study of respondents' search activity in browsers and the arrangement of data (Seghayer, 2020). Available studies suggest that the use of mobile apps and digital tools in teaching leads to increased technological competence among students. Through regular use of technology and apps, students develop skills of interaction with technology, performing assignments in online learning systems, handing in papers, taking online surveys, etc. Students develop a vision of the opportunities offered by learning technology. With the completion of a new type of assignment in online learning or cloud computing programs, students expand their visions of such programs' or apps' feature sets, which involves the integration of technology into the learning process (Audrin & Audrin, 2022). The research findings address the challenges of integrating mobile technology into the learning process, connecting the context of learning and the context of working with mobile apps (such as Socrative and Plickers), messengers, social media, and browser search activity (Pedro et al., 2018). These authors use M-learning concept, emphasizing the diverse influence of devices on learning. They argue that the use of devices can have both positive and negative effects on the learning process. For example, data regarding the adverse impact of messengers (Telegram, What'sApp) on the quality of learning were presented.

Researchers discuss the specific features of TPACK-based classroom technology and reveal the special aspects of using mobile apps in the development of critical thinking skills, comprehension, analysis and synthesis, self-assessment of students' learning capabilities (Hossain et al., 2021). The system of competencies acquired by students when using mobile apps in the learning process is analyzed. The authors argue that the use of mobile apps improves student competencies, where a special role is given to the development of competencies, the ability to use the device in the learning process, the ability to adapt the classroom learning system to homework

through a mobile app, etc. In terms of the presented model of using apps in the learning process, they assume that the use of technology provides competencies common to the three levels of students' competencies—knowledge of teaching approaches, technology and learning content. That is, when a student uses technology, he or she combines own knowledge of the subjects, the skills of using the smartphone and devices, knowledge of the principles of academic program's implementation. The use of devices improves students' competence in these types of work: searching for and processing research findings on the Internet; the use of online source list technology in a variety of styles; using university databases to obtain information; working in small groups to complete class assignments; creation of slides and their online presentations, arrangement of feedback upon completion of the training program.

The use of mobile apps in data analysis and processing was described as an important phase of data handling. Special aspects of online records in conducting research were studied. With Tess's e-notes, the most important features for data processing include the ability to process individual online responses, group responses and notes, group comments about the presented information, and the use of links to the respondents' answers (Chien, 2021).

The tendency to describe and classify the research findings of other authors is interesting and important (Arici et al., 2019). They arranged research available on the relationship of the concepts of "education", "computer", "mobile app", "virtual reality", "project", "teaching", "interaction", etc. The authors identified such concepts as crucial in research publications regarding the use of technology and apps in the learning process.

Various scholarly pursuits suggest a comprehensive integration of instructors and learners into the personality's functioning context in the twenty-first century (Sullivan et al., 2021). Research publications also discuss special aspects of the use of social media and technology to adapt student's personality to current demands (de Mesa & Jacinto, 2020). The use of social media is a technology relying on which students choose the most relevant information regarding the class assignment, the most relevant researchers to prepare for classes. Such specific nature of social media is due to the data collection and processing systems in social media where large arrays (including the history of individual views and comments) is collected, on the basis of which the student is given the most relevant search results.

The use of game technologies (e.g. Minecraft, Codemonkey, Code.org, CityXProject, Screeeps) and virtual reality components of the learning process is an important focus area. For example, the influence of virtual reality experiences and game technologies in the development of positive self-attitudes among students, building their creative approaches to solving learning task is studied (Alt & Rachel, 2020). The longitudinal study conducted by these authors proves the effectiveness of the game technology in developing of a positive self-concept among students. Similar results were obtained regarding the use of Minecraft technology in the learning process (Bile, 2022). This is implemented in the following arguments. Minecraft is based on cubic logic, which means that the smallest element in Minecraft consists of a cube (or block) of another material. Complex designs can be created by delivering multiple blocks into space. Players are free to move around, create buildings and objects, freely choosing the type of material and in

some cases using “chemistry” to create them. Minecraft offers an opportunity to play with the keyboard and mouse, with programming (available languages: MakeCode, Python, and JavaScript), which expands students’ competence in digital tools. This game technology was used to develop among players the following competencies in information science, geometry, and mathematics:

- 1) information science (knowledge of basic terms of technical information science; ability to translate an analyzed simple problem into computer language (Make Code); ability to translate an analyzed complex problem into computer language (Make Code));
- 2) geometry (knowledge of basic technical geometric terminology; ability to analyze simple geometric figures and break them down into basic parts; ability to analyze complex geometric figures and represent them as a combination of simpler geometric figures);
- 3) mathematics (knowledge of basic technical mathematical terminology; ability to diagram simple problems in mathematical form and perform numerical calculations).

Researchers discussed the opportunities offered by digital tools in developing teacher-student emotional exchange skills in the learning process using technology to analyze instructors’ and students’ narratives (Sargent & Lynch, 2021). They came to the important conclusion that the learning process should take into account the subjective attitude of students to the course content/learning resources and communications with the instructor, which can be effectively implemented with Moodle, Campus Pack Wiki, SPSS for Windows, ATutor, Eliademy. The uses of special technologies and programs (Web 2.0 general tools and Web 2.0 music tools) to develop student expression in music education, which once again proves the effectiveness of the use of technology in the learning process, were also described (Guillén-Gámez & Marta Ramos, 2021).

The research focus on the difficulties and willingness of students and instructors to use technology in the learning process is also important for our paper (Blayone et al., 2018). The authors identified profiles of people with different levels of willingness to use technology in the learning process and described scenarios for students’ entry into the situation of using technology in learning—improved planning, variety of data processing, development of models, etc. As part of the implementation of Framework for Digitally Mature Schools (FDMS) program, general indicators of the learning environment’s willingness for the introduction of information technology were discussed (Redjep et al., 2021). These authors considered such components of the learning environment’s readiness to implement technology—planning, the use of technology in the learning process (teaching), the development of technological competence, information culture and the educational institution’s technological infrastructure.

Research also presents findings on adult learners’ willingness to use computer and mobile technology (Campus Pack Wiki, ATutor, Eliademy) in the learning process (Eynon, 2021). A lower willingness among adult students, as compared

to adolescents and young men, to use technology in learning was observed, which is attributed to a poorer proficiency of adults in digital tools. In this context, it is important to identify the system of the effectiveness drivers pertaining to inclusion of technology in the learning process (Durak & Seferoğlu, 2020). The system of drivers depicts the integration of social discourses, values, and media use in the context of developing technological competence (Khan & Markauskaite, 2017).

Instructors' willingness to use technology and mobile apps in teaching was also addressed in various research (Prestridge, 2017). Available studies reveal specific features of anxiety factors among instructors regarding the introduction of technology in the learning process:

- 1) a sense of incompetence about the use of technology;
- 2) the difficulty of adapting instructors to new technologies (building skills to use devices);
- 3) the need to vary the methodological system to both classroom-based and technology-based instruction (Henderson & Corry, 2021).

Furthermore, the system of factors that prevent instructors from integrating into a technologically designed learning process has been studied. The crucial factors identified are: adoption of innovations; getting benefits therefrom; compatibility of innovations with the academic programs developed by educators; autonomy of students and instructors; effectiveness of innovations (Chou et al., 2019).

The effectiveness of mobile apps (in particular, Tabata Timer, Nike Run Club, Adidas Running, Endomondo, Sworkit, Just 6 weeks) in online learning is proved by a significant increase in learning outcomes when using technology (Bobkov et al., 2021). Based on the experiment's outcomes regarding the introduction of technology in the learning process, the authors suggest that 92% of students pointed to an increase in their academic achievements. Researchers also suggest the increase in the learning effectiveness when mobile apps were used in the learning process (Danilina & Seregina, 2017).

The opportunities offered by technology and mobile apps (e.g., ensuring constant contact between the instructor and students, the ability to work remotely, the ability to create various tasks, etc.) emphasize the need for their implementation in the educational learning process, especially in higher education (Baguma et al., 2018; Cubeles & Riu, 2018; Khalid & Pedersen, 2016).

Yet, the problem of finding optimal technologies for implementing mobile apps in the learning process remains poorly understood and requires further research.

1.2 Problem statement

This study was conducted to expand evidence-based data regarding the use of mobile apps in the learning process in higher education, because, despite the relevance of this topic and available research, many components of this technology's implementation in education were ignored.

The paper analyzes the teaching experiment regarding the use of mobile apps in the assessment of student learning.

Pursuant to the research goal, the following objectives were defined:

- 1) reflect the evaluating the effectiveness of Socrative and Plickers mobile apps tested in a teaching experiment with students;
- 2) investigate students' attitudes toward using mobile apps in assessing the quality of their learning.

Solution of these problems reveals specific features of using mobile apps in assessment of learning activities in higher education. In addition to describing the effectiveness of mobile apps in improving the quality of education, the analysis of the survey outcomes will make it possible to identify the typical difficulties faced by instructors when implementing relevant technology in the learning process. Accordingly, knowing these difficulties makes corrective work to improve the instructors' willingness to use technology in the learning process in higher education possible. On top of that, the obtained data regarding students' self-assessment of mobile apps used in the learning process will make it possible to identify the strengths and weaknesses of relevant technologies used in the learning process.

2 Methods and Materials

2.1 Research design

The study of the special aspects of mobile apps when used in the assessment of students' knowledge involved a teaching experiment. The study relied on the experimental method, the surveys (respondents' answers to the formulated questions) and self-reported data (description, in a free form, of the participants' attitude to the research situation). Fisher transformation was used to assess the statistical significance of differences.

2.2 Sample

The study involved 320 s-year students of the I.M. Sechenov First Moscow State Medical University. The sample members were 18–20 years old, with 202 male and 118 female students. The sample members were selected on the basis of the following criteria: voluntary participation, random selection of sample members from the population, students' ability to use cutting-edge technology (smartphones with Internet access). The second-year students were chosen for the experiment, since the first-year students are just beginning their studies, and the use of new technologies by them was considered inexpedient for the purposes of this study. Senior students are preparing for graduation, and the experiments may have distracted them from their studies. Second-year students, on the other hand, unlike first-year students, already possess learning experiences, which is

important because it will be easier to compare the effectiveness of learning with and without the apps. Yet, they are not graduate students and are not in the process of finishing their studies. The study involved students majoring in Medicine, Dental Medicine, Preventive Healthcare, Pediatrics.

2.3 Survey

The study involved the following phases.

1. In the first phase, experimental and control groups with equal number of members were chosen. The experimental group consisted of 160 students who were taught using mobile apps, while the control group consisted of 160 students who were taught in a conventional offline format.

The experiment was conducted between September 1 and December 28, 2021, during the academic semester.

2. Implementation of the experiment. During the first semester of 2021–2022 academic year, a number of disciplines (Fundamentals of Human Physiology, Developmental Psychology, Propaedeutics of Internal Medicine) were taught using Socrative and Plickers apps. These apps are free and enabled the learning process, particularly in online format. The education itself took place in a face-to-face format. That is, the experimental group learned in a blended format, when students were both present in the classroom and used mobile apps.

While working with the experimental group, instructors set up classes with students in these apps and used these technologies. What made the Plickers app special was that it enabled setting up classes of up to 63 persons, allowed for immediate scanning of student responses online and provided feedback for students, gave assessment results in percentages per group, etc.

Socrative is designed for a maximum of 50 students in a single virtual classroom at a time and also enabled performing learning assignments, testing, assessment of students' teamwork. In the experiment, virtual classes were set up within academic groups to ensure that the learning process was similar to the control group. Free demo version of this app was used.

Eight instructors worked with the experimental group, interacting simultaneously with students face-to-face in the classroom and in the Plickers and Socrative apps.

Students in the control group (160 persons) learned through face-to-face interaction between the instructor and students without mobile apps.

3. Survey phase. At this phase of the experiment, the survey was conducted among members of the experimental and control groups in order to measure the effectiveness of the apps used in the learning process. Members were interviewed face-to-face using special forms to ensure equality between the experimental and control groups.

Table 1 Flowchart of the influence on learning among the experimental group students

Program components	Contents of the work in the apps	Skills developed at this phase
Introduction to Socrative and Plickers apps	Getting to know Socrative and Plickers apps, joining students in classes, completing trial assignments, linking student accounts into groups, etc	The skill of primary interaction with mobile apps, the ability to create and use an account, performing tasks
Using Socrative and Plickers in the Fundamentals of Human Physiology	Using real-time surveys, online presentation of results in academic group, using Space Race, creating Microsoft Excel documents, students' teamwork in real time, adding graphical objects to text files (when studying the nervous system's evolution, models, combined with its textual description, were created), maintaining a journal of grades and writing module tests throughout the course	Skills in working with apps, teamwork with Socrative and Plickers apps, ability to integrate graphical objects into text files, performing various forms of control (current and final) using mobile apps, working with Microsoft Excel and its integration into Socrative and Plickers. Assessment and journal maintaining skills (for instructors)
Using Socrative and Plickers in Developmental Psychology	Using real-time surveys, online presentation of the results in an academic group, adding graphical objects to text files (when creating models of experimental research into the person's lifespan development and building a model of developmental psychology methods), maintaining a journal of grades and writing module tests throughout the course	Skills in working with apps, teamwork with Socrative and Plickers apps, ability to integrate graphical objects into text files, implementing various controls (current and final) using mobile apps. Assessment and journal maintaining skills (for instructors)
Using Socrative and Plickers in the study of Propaeutics of Internal Medicine	Using real-time surveys, online presentation of the results in an academic group, adding graphical objects to text files (when creating models of experimental research into the person's lifespan development and developing models of prevention and the course of diseases), maintaining a journal of grades and writing module tests throughout the course	Skills in working with apps, ability to integrate graphical objects into text files, performing various forms of control (current and final) using mobile apps. Assessment and journal maintaining skills (for instructors)

To determine the impact of mobile apps on the quality of student assessment, a survey was conducted and a self-reporting writing assignment was provided to participants. The questionnaire consisted of one part.

The questionnaire contained the following questions:

1. Do you believe the use of mobile apps improves the quality of education and assessment of knowledge? Researchers were offered only two options—“Yes” and “No”.
2. Do you feel that using Socrative and Plickers mobile apps contributes to a better learning experience? (because using apps makes it possible not only to learn the course content, but also to work with it online in real time).
3. Would you say that using Socrative and Plickers apps can improve motivation to learn? (the point is that learning with the app is more interesting and desirable for a student than learning in the classroom without the app).
4. Do you think using mobile apps is convenient because it gives you the opportunity to work with the course content both in the classroom and at home?
5. Do you believe that the use of mobile apps enhances a student’s digital competence as an important professional quality that ensures students’ competitiveness in the job market?

These questions were chosen to explore the basic characteristic features of a mobile app in the learning process - its effectiveness in learning (1), improved learning of the course content when working with it (2), motivation to learn through diverse data processing (3), app’s convenience (4), improved digital competence (5).

The self-report method was used in terms of different assignments for students and instructors.

For students, the assignment for writing a self-report was as follows: You need to describe how you feel about managing learning through mobile apps. In doing so, you need to specify your personal attitude to the experiment, evaluate the role of mobile apps in knowledge delivery, describe the benefits or difficulties you personally have experienced with the use of mobile apps in the learning process. Also, you can write down any thoughts and comments you have about the use of mobile apps in the learning process.

For instructors, writing a self-report included the following assignment: You need to describe your personal relationship to the process of using mobile apps to support the learning process. Please specify the advantages and disadvantages of using mobile apps, the difficulties you encountered during the experiment. Any comments you have about the study are important.

The processing of self-reported data involved their analysis and the identification of semantic categories of the participants’ responses. Yet, participants’ answers, similar in semantics, were grouped into the same categories, despite possible differences in wording and chosen words. At this point, the participants’ answers were administered without the use of special software.

4. The phase of calculating and interpreting research data. The results of the student and faculty survey were processed during this phase. To compare the responses of

the experimental and control groups, percentage values were calculated, and the statistical significance of differences was estimated using Fisher transformation.

2.4 Statistical processing

Statistical processing of data in the experimental and control groups was performed using SPSS for Windows (version 26.0). Grouped tables made it possible to determine the necessary data and make calculations. The grouping of data leads to findings based on the calculation of the obtained results and their qualitative analysis.

2.5 Research limitations

This experiment is not subject to any significant limitations, although it is assumed that the specific nature of the learning process might have affected the findings. The point is that the use of mobile apps and the assessment of students' progress could not always be implemented solely with the app. Learning the course content also involved face-to-face interaction between the instructor and the students (for example, when studying the Fundamentals of Human Physiology, all the work could not be performed through the app, as students had to work with models, work in lab classes with real objects, which was combined with the work in the app, etc.). Therefore, it turns out that the experimental group was engaged in blended learning, when the learning itself took place in a face-to-face interaction and in a virtual classroom. What has not changed is that the grading and writing of tests and quizzes has always been done in mobile apps. The control group did not use the apps at all, and the learning process always had a format of face-to-face interaction between the instructor and students.

2.6 Ethical issues

This study meets ethical standards, and the experimentation itself does not address problematic and ethically significant issues for the students or the instructor. Confidentiality of data was not jeopardized, the rights and freedoms of participants were not violated either.

3 Results

Table 2 shows the experimental and control group members' responses that reflect the effectiveness of Socrative and Plickers mobile apps tested in a teaching experiment with students.

Table 2 suggests that 69.3% of experimental group students believed the use of mobile apps in assessing knowledge was effective ($\varphi^* = 11.26$, $p \leq 0.01$). They believe that using apps with constant access to their grades, the grading system's flexibility, and access granted to the student and the instructor make it possible to improve the quality of learning. Yet, 30.7% of the experimental group students

Table 2 Evaluating the effectiveness of Socrative and Plickers mobile apps tested in a teaching experiment with students

App operation parameters	Experimental group	Control group	φ^*
Effectiveness in learning	69.3%	12.8%	11.26**
Improving the learning experience	72.2%	24.3%	8.94**
Motivation to learn through diverse data processing	66.2%	24.1%	7.6**
App's convenience	81.2%	12.3%	13.66**
Improved digital competence	65.3%	52.1%	2.4*

mentioned that the use of mobile apps does not affect the assessment of the quality of student knowledge in any way. They argue that the traditional model of learning and face-to-face teacher-student interactions, with the recording of learning outcomes in a journal, is quite effective for learning.

Furthermore, experimental group members also provided other significant parameters of the Socrative and Plickers apps. The students mentioned that the apps do contribute to: better learning ($\varphi^*=8.94$, $p\leq 0.01$); developing cognitive motivation among students resulting from diverse learning resources used with apps ($\varphi^*=7.6$, $p\leq 0.01$); convenience of learning activities because students can work with the app both in the classroom and at home ($\varphi^*=13.66$, $p\leq 0.01$); improved digital competence ($\varphi^*=2.4$, $p\leq 0.05$). Therefore, the resulting data reflect a rather strong feature set of Socrative and Plickers mobile apps. They are functional, user-friendly, stimulate motivation among students and promote digital competence.

Table 3 presents the students' self-reported data on the results of implementing Socrative and Plickers mobile apps during the teaching experiment.

Table 3 Students' attitudes toward using Socrative and Plickers mobile apps in assessing the quality of their learning activities

Indicators of student attitudes	%
It is convenient for me to see, at any time, which types of work are graded and which are not	34.2%
The learning assessment system is becoming more clear to me	32.1%
With the mobile app, I can study both at university and at home, having all the learning resources	31.9%
Mobile technology in education makes sure that learning keeps pace with technological change	26.4%
Mobile apps for evaluation—that fits me	22.4%
Using mobile apps in learning is interesting	18.6%
With mobile apps, I can easily learn about technology	14.7%
With apps, I develop the technical skills needed to harness the technology	12.8%
With mobile technology, it's easier for me to connect with my instructor	10.8%
Apps interfere with my studies because I have to be constantly distracted from my studies to use them	8.6%
I do not see a significant difference—a grade is a grade	8.2%

Table 3 suggests that most of the categories in students' self-descriptions reflect a positive attitude toward the use of mobile apps in the learning process. The most pronounced are respondents' descriptions of apps' usability (choice of types of work (34.2%) and ability to work from home—31.9%), ease of understanding the grading system (32.1%), alignment with technological change (26.34%) and student requirements to the use of devices (22.4%).

Therefore, the crucial findings of the teaching experiment for students include the app's usability and the students' knowledge of the assessment system. They continuously see which assignments have not yet been assessed, and which assignments have been given average, high or low grades. Therefore, this app makes it convenient and clear to students what tasks they need to complete to improve their performance. The use of apps in learning is important because it reflects the young people's commitment to keep up with the times and the trends of technological change.

Especially important for students is the category *Mobile apps for evaluation—that fits me* (22.4%). The statements that make up this category are consistent with the particular motivation of students. When using mobile apps in learning, their devices turn into learning tools, or a learning technology rather than unwanted items in the classroom. Students are simply interested in using such apps because they meet their interest in various technologies.

Less pronounced are the categories that reflect the positive effect of mobile apps on young people's overall ability to use devices (12.8%) or establish a positive relationship with an instructor (10.8%). These data may be interpreted as follows: since it is quite acceptable and usual for students to communicate with the help of technology, which is psychologically comfortable for them, then the communication with the instructor via chat or messages in the app reminds the student of the system of communication, which is usual for him/her and causes positive emotions.

That is, the apps really perform organizational, communicative and motivational functions in the learning process.

Categories of self-descriptions that reflect students' negative attitudes toward the use of technology were identified. Such categories of self-description reflect the student's need to pay attention in addition to learning and work in the app, which distracts them (8.6%). Alternatively, some students mentioned that they saw no inherent differences between an app-based grading system or face-to-face interaction with the instructor (8.2%).

Table 4 presents the results of educators' self-descriptions regarding the mobile apps' role in the learning process.

Table 4 shows that the categories used in faculty's description of the role of Socrative and Plickers apps in student learning have slightly different semantics. The most pronounced are the categories of the apps' convenience (the app can be used both at home and university—75%) and their ability to provide didactic objectives and implement them in the learning process (62.5%). Instructors realize that the traditional teaching system does not meet students' demands for relevant, interesting professional knowledge in an exciting and modern way. Today's students are no longer interested in simply reading and answering (either orally or in writing) in a class. Students are especially interested in using cutting-edge technology. In this case knowledge becomes more intense for them, and the students themselves

Table 4 Instructors' attitudes toward using Socrative and Plickers mobile apps in assessing the learning's quality

Indicators of instructor attitudes	%
The mobile app improved my teaching performance	75%
The mobile app is user-friendly because I can grade papers both at university and at home. There is no need to use paper	75%
I can adapt my teaching based on what students currently understand or do not understand	62.5%
My curriculum has made me think more deeply about how technology can affect the teaching approaches I use in the classroom	62.5%
Mobile apps improved my user experience with devices	62.5%
The app makes it easy and uninhibited for me to communicate with students, as it does for them in communicating with me	50%
I can choose the technologies that will maximize the quality of teaching	50%
Feeling intimidated by appearing incompetent in technology	32.5%
Using mobile apps is time-consuming because of the need to duplicate grades in both the app and the journal	25%

become motivated and interested. An important point for teachers is the ability to maintain relaxed communication with students (50%), stay with them in psychological contact and in a virtual reality environment familiar to students.

Educators mention that the use of mobile apps impacts their proficiency in cutting-edge technology (62.5%). Instructors are more likely to say that using apps has improved their technology skills. Less frequently, educators say they are afraid of showing incompetence in using devices (32.5%).

Relying on such data, a good case can be made about the pronounced didactic opportunities offered by mobile apps in the assessment of students' learning experience, which is the paper's main idea. First, the use of mobile apps to assess student knowledge can improve its quality. For students, it gives a sense of community with technological change, provides a comfortable learning experience, and allows for relaxed communication with educators. On the instructor's part, attention is drawn to the pronounced didactic opportunities offered by mobile apps in assessing students' knowledge, the possible use of the app to improve technological competence and establish optimal psychological contact with students.

4 Discussion

The findings are consistent with most studies in this area. Therefore, other studies have also revealed a positive impact of mobile apps on the quality of learning. The authors also obtained evidence of improved learning and assessment through mobile apps. Based on the results of mobile apps use, researchers revealed a 7.5% decrease in the students' academic failure rates in physical education (Bobkov et al., 2021). These authors also observed improved learning experience and motivation. Responses and categories highlighted by educators in the conducted study correspond to the didactic features of mobile apps used in the learning process (Danilina

& Seregina, 2017). The findings of the research conducted using Socrative and Plickers apps, as well as the findings of these authors emphasize the apps' feature set and innovativeness; ability to meet the student's needs for relevant and interesting knowledge in a proper and interesting way; providing real-time assessment and monitoring of learning activities. Other characteristic features of Socrative and Plickers apps are also discussed in these authors' research, including the ability to transfer data in different formats, predict students' capabilities. In this paper, such app features were not highlighted by respondents.

The findings are consistent with those of Swedish researchers, who identified, as in the case presented herein, the importance of mobile apps in meeting students' technology needs, allowing them to learn more conveniently, communicate with instructors and see the grading system holistically, learning both in the institution and at home (Bergdahl et al., 2020).

The resulting empirical data are not consistent with the findings of U.S. researchers, who point to anxiety regarding development of various addictions (Internet, virtual reality and devices) in the use of technology in learning (Cladis, 2020). None of the respondents (neither students nor instructors) mentioned this trend. On the contrary, the students pointed to the importance of using mobile apps, when the "forbidden device" becomes a necessary component of the learning process (interpretation of the data in Tables 3 and 4).

The authors' findings are consistent with those of the Canadian authors, who highlight different strategies of instructors' and learners' coexistence with mobile apps (planning activities, creating models and a variety of data analysis), which partly reflects the findings in the described study (Blayone et al., 2018). Data similarities come out of the fact that mobile apps allow for better planning of learning activities, modeling of learning experience, and providing a variety of data analysis. The Canadian authors point to the importance of task flexibility in the apps, which is almost not discussed in the survey of students, but is very well identified among the educators included in the sample in the study presented herein (Blayone et al., 2018). They also discuss the importance of students' and educators' willingness to use mobile apps and technology in learning. The instructors' concerns about their own willingness to use mobile apps in the learning process, identified in the described study, are also discussed by the Chinese authors (Chou et al., 2019). They also, identified the importance of such innovations in the learning process and the role of apps therein, which is consistent with the results of this study (Tables 3 and 4)—the app's ability to help to keep up with the advancements in research and engineering, to improve learning motivation, to enjoy a positive didactic effect while working with apps. These authors also discuss the instructors' and learners' autonomy in case of app-based learning and teaching. Tables 3 and 4 do not describe such categories due to the absence thereof in respondents' self-descriptions, but the topic of independent studies using the app in the classroom and at home is perceived as one of the benefits of using mobile apps to assess the quality of education. Chinese researchers emphasize the culture of innovations as an important component of the technology use. Such results are not presented in the tables pertaining to the study, but a number of categories were identified in the self-descriptions that reflect the appropriateness of uses to technological change (Chou et al., 2019).

Comparison of the resulting data with the other studies' findings helps to evaluate them as follows. The findings suggest that the use of Socrative and Plickers apps in the learning process is an important and indispensable element of the contemporary theoretical knowledge and practical implications of education. Their use makes it possible to diversify the learning process. For example, students do not just prepare for workshops, but combine (online in real time) text and graphic objects, create shared documents, where everyone does own part of the work. A psychological contact emerges between the instructor and the student—it is easier for students to communicate with the instructor online, which is familiar to them. Flexibility is observed in the ways of doing things together when learning (not just “outline the answers to the workshop questions”, but “develop a model”, put together text and graphic objects, and create an intellectual property item in an online format). Teaching with apps allows the instructor to give students interesting information in an original way, meeting the young people's needs to use devices in everyday life and education. An important point is that the experiment revealed the specific motivation among students—the smartphone's transformation from a device that interferes with learning and is not welcome in the educational institution into the learning tool.

5 Conclusions

The research findings can be summarized as follows. The use of Socrative and Plickers apps is a pressing issue in today's environment, as evidenced by the large number of research papers on the topic.

The important role of mobile apps in managing the learning process within a university was determined. That is, the apps really perform organizational, communicative and motivational functions in the learning process. Respondents' self-descriptions disclose important characteristic features of Socrative and Plickers apps when used for learning: convenience (81.2%); feature set (72.2%); student and instructor access to the learning process in the classroom and remotely (31.9%). Socrative and Plickers apps also allow learners to: establish psychological contact (10.8% of students and 50% of instructors); improve technological competence (12.8% of students and 32.5% of instructors); strengthen cognitive motivation among students (18.6%). Instructors may demonstrate and implement various didactic technologies (75%).

The study has important research and practical implications. The findings might be further relied on by other researchers in identifying the didactic opportunities offered by mobile apps in the learning process. Quite important is to highlight the difficulties faced by educators and students when using mobile apps, which requires further study. The adverse aspects of self-description in the role of mobile apps in teaching are worth emphasizing in further research.

The practical implications of this study involve possible use of these apps in universities, as their effectiveness has been validated by feedback from the experiment participants.

The research findings can be used by instructors in universities and secondary schools. Since didactic opportunities offered by mobile apps are quite significant, and considering other positive results of their use, this technology may be

considered as an important tool for training young people and strengthening their cognitive motivation.

The study was conducted on the basis of a specific university, however, can be generalized. Despite the variety of resulting data, the use of mobile apps in assessing learning activities remains unresolved and requires further research. Further research might focus on the specific features of learning and professional motivation when using mobile apps for learning.

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Data availability Data will be available on request.

Declarations

Conflict of interests Authors declare that they have no conflict of interests.

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