The educational impact of using mobile technology in a database course in college

Spartak Sakibayev, Razakh Sakibayev and Bela Sakibayeva
Zhetysu State University named after I.Zhansugurov, Taldykorgan, Kazakhstan

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Abstract

Purpose – Nowadays, when mobile devices are actively evolving and penetrating the various spheres of human activity they have a potential to modernize and facilitate the sphere of IT education as well. This paper aims to test the hypothesis stating that introduction of mobile technology to the college-level database course for future IT specialists has a positive academic impact on students.

Design/methodology/approach – The main theoretical premises for the present study were the general findings of the surveys by Hinze *et al.* (2017) and Bowen and Pistilli (2012) indicating that: using mobile tools to work on classroom projects improves student's academic success students, especially those from computing specialties, actively turn to mobile tools in their academic activity students favor the Android and iPhone platforms and prefer native mobile apps to Web-based mobile apps The key idea of the present study was to validate these general premises in the specific case of the college-level database class. Namely, the authors formulated a hypothesis that Android-based mobile devices have a positive impact on the IT students' academic performance and interest in the subject at the college-level introductory database lessons. Throughout the study, the authors examined both quantitative (students' scores and attendance rate) and qualitative aspects (students' and teachers' opinions) of the hypothesis.

Findings – Based on the experiment's positive outcome resulting in students' increased academic performance and interest in the subject, the authors conclude that in the context of the college-level database course mobile devices can successfully substitute traditional desktop computers and positively affect students' academic activity.

Originality/value – Based on the experiment's positive outcome resulting in students' increased academic performance and interest in the subject, the authors conclude that in the context of the college-level database course mobile devices can successfully substitute traditional desktop computers and positively affect students' academic activity.

Keywords Mobile devices, College students, M-Learning, Mobile technology in education, Modernization of IT education

Paper type Research paper

1. Introduction

This work is dedicated to the effective integration of mobile technology (mobile phones and tablets) into the educational process of future information technologies (IT) specialists. More specifically, it covers the experiment conducted to test the usage of mobile phones for creating and managing databases in the introductory database course for the second-semester IT students of the department of computer science from a local university where

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the authors work. The main purpose of the work is to verify the validity of the authors' hypothesis stating that the introduction of mobile technology to the college-level introductory database course has a positive educational impact on the IT students. "Everywhere in the text the authors use the term 'college-level' in the sense of the educational program for undergraduate students." The desired positive impact would be the increase of the students' academic performance, attendance rate and their interest in the subject.

Recently, mobile technology has turned into one of the priorities in the development of the modern IT industry. According to Katz *et al.* (2014), Merchant (2012) and Traxler and Vosloo (2014), mobile phones worldwide are actively penetrating various areas of human activity, such as entertainment, commerce, marketing and electronic government services and have been heavily used both by adults and adolescents in their everyday life. In this process, it has become evident that mobile devices successfully perform many of the tasks associated with traditional desktop computers. Also, existing technologies enable desktop computers to synchronize and share the large chunks of data online; thus, simplifying the process of reorientation toward mobile devices.

As can be summarized from Ott *et al.* (2014) and Lawlor (2017), during the past decade, traditional computer classes have often been replaced by classes based on mobile devices as the sphere of education at the global scale has been affected by the mobile trend. Bowen and Pistilli (2012) report that modern educators view mobile-based learning as the future of learning and, as is stated by Hahn (2014), in their current state mobile technologies have matured enough to serve as suitable tools for the academic purposes. Besides, according to Jesse (2015), around 99 per cent of college students own mobile phones and even during their lesson time bring their mobile devices with themselves and use them during the class work, as reported by Ott *et al.* (2014) and Thomas and Muñoz (2016). Taking into consideration this predilection of students' community for the wide usage of mobile devices, it is natural that educators search for better ways to integrate the mobile technologies into the existing methods of instruction to facilitate the academic process.

It is fair to assume that presently in the college-level context mobile devices are still not used in a way that allows them to unleash their full instructive potential. Hinze *et al.* (2017) report that in their extracurricular time, students frequently use their mobile devices for non-learning activities. In addition, most of the time in the classroom these devices are used merely for viewing some form of educational content. For example, a student may visit an educational site, read an electronic textbook, play an educational multimedia file or view a presentation with lesson-related material. The instructive effect of such use cases is minimal as students only passively absorb the learning material. Teachers are often reluctant to find more creative and beneficial (from the educational standpoint) ways to apply mobile technology to the educational process. In the college-level classroom mobile devices are often considered to be unsuitable for accomplishing more advanced technical tasks despite the fact that they have long provided sufficient computing resources on par with desktop PCs. Such a limited view on mobile usage in the academic environment leads to a serious drawback in the advancement of the educational information technologies. As a result, it also negatively affects the overall process of training future specialists by an educational institution.

The present work is dedicated to the elimination of the shortcomings in mobile learning practices mentioned in the previous paragraph and focuses on doing it exclusively in the context of the academic process of the college-level IT students. It examines the educational advantages, which the usage of Android-based mobile devices brings to the college-level introductory database course. The authors describe the methodology used to introduce

these devices to the database lessons and then analyze data related to the academic scores obtained by the students under this mobile-based approach to learning. The authors' methodology is based on their hypothesis that Android-based mobile devices represent an effective tool for increasing IT students' academic performance in the introductory database course. The concepts for this hypothesis come mainly from the findings of the surveys by Bowen and Pistilli (2012) and Hinze *et al.* (2017), stating that on the whole students feel positively toward using mobile devices in their learning activities and that it is, namely, students from computing specialties that are the most active practitioners of this mobile-based approach. The novelty of the study lies in its treatment of mobile devices not only as the auxiliary means for passive absorption of learning material in the college-level IT-related classes but also as a full-featured alternative to traditional desktop computers capable of performing advanced technical tasks such as development and management of databases.

2. Literature review

The topic of using mobile technology in the educational environment has been a focus of a significant amount of the published research. The majority of researchers agree that mobile-based learning provides an effective methodological approach, profitable both to teachers and students.

Hinze *et al.* (2017) report on the results of the survey about mobile application usage by students and academic staff at the University of Waikato, New Zealand, with 138 respondents taking part in the questionnaire. The survey was held in the two-week timeframe selected as a period when students and academic staff were most likely to participate. The results of Hinze *et al.* (2017) demonstrate that mobile devices (primarily based on Android and iOS systems) have a widespread adoption in the university's educational and scientific communities and that students, educators and researchers actively use mobile applications in their academic and research activities by sharing documents with others, accessing course information, referencing, making information presentations, writing literature reviews, managing projects and assignments, note-taking and performing data collection and analysis. In addition, it is, namely, respondents from the department of computing, which are among the most active participants and beneficiaries of using mobile applications for their activities. In the same survey, about 50 per cent of respondents report to believing that the process and outcome of their teaching or research activities are impacted by using mobile applications. The findings of Hinze *et al.* (2017) prove the positive role of mobile technology in the development of students from computing specialties and the present study enhances these findings by showing that it is database students, in particular, that benefit the most from mobile learning.

Limtrairut (2018) makes an emphasis on designing iPhone-based mobile learning applications for use by the computer science students. These applications allow students to learn educational material through various interactive and visual means such as quiz game and multimedia content. The article's findings demonstrate that the iPhone-based mobile applications positively affect student engagement with the lessons. The present study enhances on some of these findings by extrapolating them to the Android platform and applying them to the specific context of a database class.

Oyelere *et al.* (2018) focus on describing MobileEdu, an Android-based mobile application used in a Nigerian university to facilitate the learning process of computer science students in the mobile technology course. MobileEdu enables teachers to deliver an educational content for the course with the help of interactive means. The paper covers the design and main use cases of MobileEdu and emphasizes its positive impact on students' academic

performance. The current work contributes to the findings of Oyelere *et al.* (2018) by validating them in the design of the mobile front-end used by the students from the current work's target group in their database course.

Zaldivar *et al.* (2015) describe a survey conducted at the Faculty of Computer Science (Facultad de Informática) of the Universidad Autónoma de Sinaloa, México with the purpose of evaluating the impact of mobile technology on daily lives and academic activities of computer science students. The survey was organized through interviewing 152 respondents including teachers and students. The majority of the respondents confirmed the positive impact of mobile-based learning platforms, for example, Moodle, on their academic performance. The present work contributes to the survey's results by confirming the positive impact of mobile learning on academic performance of students in the database class.

A questionnaire conducted by Jordaan (2014) among computer science students of a South African university campus shows that they have a positive attitude toward the use of mobile technology in their classes and realize the potential educational benefits of mobile learning. However, despite this overall positive attitude, about 70 per cent of the questionnaire's participants commented that their teachers should find more creative ways of using mobile devices in a classroom. The present study proposes one of such creative ways for using mobile devices – development and management of databases.

Greek researchers Lytridis and Tsinakos (2017) state that mobile technologies create new opportunities for learning and describe the design and implementation of mLearn, an Android-based mobile learning platform for conducting educational field trips, both indoors and outdoors. This platform can be used by the students during the field trip to access the teacher-prepared educational content through investigation of the various points of interest or by scanning the QR codes depending on the type of activity. The article shows that native Android mobile applications can be successfully used to provide both teachers and students with an effective learning platform. Lytridis and Tsinakos (2014) discuss the question of integrating the concept of mobile learning with a real-life commercial Android-based mobile application. It presents a methodology, which allows non-formal heritage education to benefit from a commercial mobile application. Lytridis and Tsinakos (2014, 2017) describe the features of mobile applications, which are tailored for viewing the learning content and some of them were used in the development of the current study's front-end. At the same time, the present study enhances the findings of these both papers by showing that such applications can also be used for effective creation of the learning content requiring the database connectivity.

Turkish researchers Ozlem Ozan and Demiray (2015) stress out that in mobile learning, the emphasis is to be put on the mobility of the learners, rather than devices and that the main advantage of mobile platforms is that they allow the learners to get engaged in the educational activities without experiencing the constraints of delimited physical location. The same paper calls mobile-based learning as one of the latest stages that modern information society has reached. The findings from Ozlem Ozan and Demiray (2015), which influenced the present article were the examples of the cases where mobile devices (including the Android-based devices) were used for tasks often assigned to IT students in their coursework such as data collection and analysis. The present article enhances these findings by demonstrating that it is also possible to successfully use mobile devices for managing and processing data in the database course as well.

Subramanian and Rajesh (2015) present the results of the study concerning the smartphone usage by college students in Chennai, India. The study involved 115 students of

both sex and examined both positive and negative aspects of using smartphones in the college-level environment. Though the study is not dedicated, particularly, to students from computer science specialties, it affected the present article by noting that the portable nature of smartphones facilitates the academic process by enabling students to browse academic material and take part in their lessons from any place, not necessary the classroom. The present article contributes to the results of Subramanian and Rajesh (2015) by demonstrating that it is the database lessons of IT students, in particular, that can benefit greatly from the ability to do the lesson assignments outside the classroom.

MacNeill (2015) studies available methods of the most effective usage of mobile devices by academic staff and suggests that educators and researchers should treat the process of selecting mobile applications for their professional activities similar to the process of selection of specialized literature in their field. MacNeill (2015) provides useful general insight into the process of selecting mobile applications required for academic purpose and its ideas were used in the development of the present study's front-end. At the same time, the present study enhances the results of MacNeill (2015) by formulating the requirements, which a mobile application for the college-level database course, in particular, is to meet.

Rakibul *et al.* (2017) conduct research on the smartphone usage among students from 18 to 25 years of age from universities and colleges in Bangladesh. They come to the conclusion that attentive students with good academic profile have better chances to use their smartphones for useful academic purposes than inattentive students, who are inclined to use their smartphones mostly for the purpose of entertainment. The present article enhances this conclusion by extrapolating it to the introductory database course and demonstrating that with respect to the course students with the good academic profile are inclined to put more classroom and extracurricular time to use their smartphones for increasing their knowledge in databases and as the result tend to improve their academic scores in the subject.

The study conducted by Dias and Angelin (2017) shows that students' learning process in a classroom is facilitated by the usage of a mobile device as it is an *omnipresent* constituent of their daily activities and enables learning anytime and anywhere. The study is mostly focused on using iPads for such classroom activities as accessing online educational material, viewing teachers' presentations and taking lesson-related notes. The present article enhances the findings of Dias and Angelin (2017) by demonstrating that Android-based devices are capable of facilitating the learning process of students by allowing them to easily access online educational and reference resources, helpful in doing their classroom assignments in any time and from anywhere.

The results obtained by these reviewed papers prove the positive impact, which mobile technologies have on the outcome of the educational activities in general. The present paper contributes to the published research by focusing in particular on the possibilities of a mobile device as means for facilitating the college-level database course of the IT students and demonstrating that it can be used as a valid tool for advanced and creative database-related technical tasks.

3. Methodology

3.1 Theoretical framework

The main theoretical premises for the present study were the general findings of the surveys by Hinze *et al.* (2017) and Bowen and Pistilli (2012) indicating that:

- using mobile tools to work on classroom projects improves student's academic success;
- students, especially those from computing specialties, actively turn to mobile tools in their academic activity; and
- students favor the Android and iPhone platforms and prefer native mobile apps to web-based mobile apps.

The key idea of the present study was to validate these general premises in the specific case of the college-level database class. Namely, the authors formulated a hypothesis that Android-based mobile devices have a positive impact on the IT students' academic performance and interest in the subject at the college-level introductory database lessons. Throughout the study the authors examined both quantitative (students' scores and attendance rate) and qualitative aspects (students' and teachers' opinions) of the hypothesis.

3.2 The target group

The target group of the present study consisted of two second-semester groups from *the local university* taking the same introductory database course and differing only in the language of instruction. Both groups consisted of 15 students demonstrating averagely-similar academic performance in other subjects and having Russian as their primary language of communication. The first group (referred to in the text as the Group A) had Russian as its main language of instruction. The language of instruction of the second group (referred to in the text as the Group B) was English. This English group was formed of those students who either passed the college's English examinations or obtained B and 5 (or higher) in IELTS. Considering the possible difficulties, the students of this group might encounter in understanding learning material in a foreign language, teachers repeated the main ideas of the lesson in Russian and the classroom tasks were given both in English and Russian. Both groups had never had any previous database-related lessons prior to the study period. According to the college's timetable, the database lesson in the Group B was their last lesson of the day.

By the college's standards both groups were considered to have relatively high average academic profile in mathematics and science. Also, they were considered to be relatively large in size with other groups consisting of 10-12 students.

The research was conducted in the period between January and May 2018. This time frame (referred to later in the text as *the study period*) was selected as a period when the college's database lessons, for the first time in the college's history, started switching from traditional desktop computers to mobile devices for database development, while following the previous year's syllabus. Here, and further in the text by *the previous year*, the authors mean the period between January and May 2017 when the database course still used desktop computers and was taught to groups other than the Groups A and B). The two teachers (one for Russian class and the other for English class) who taught the course in the study period were the same as those who taught the course in the previous year.

For the purpose of comparison, the present article also used the data from the previous year. The contents, the order of topics and the tasks given to students in the previous year's course were the same as the ones from the study period. The data were taken from two groups to whom the introductory database course was taught in the previous year. One of those groups used the Russian language of instruction (14 students in total and referred to later in the text as the Group C) and the other used the English language of instruction (12 students in total and referred to later in the text as the Group D).

All students and educators mentioned in the paper were informed that the results of their academic activities during the study period would serve as source data for the paper.

3.3 The college's grading system

To assess the academic performance of its students, the college uses the grading system given from the Table I.

3.4 Description of the database course

The objective of this database course is to teach the basic concepts of database development and management. Students are taught essential structured query language (SQL) statements used to create and delete databases and tables, define keys and indexes and view and edit table data. More advanced topics such as custom stored procedures, functions and triggers are not covered by the course at all. Students are expected to be able to create and a simple database, such as, for example, a personal book library catalog, and manipulate its data. In their work, students use the following SQL statements: CREATE DATABASE, CREATE TABLE, DROP TABLE, ALTER TABLE, INSERT, UPDATE, DELETE and SELECT. Prior to introducing mobile devices, students performed these tasks in Microsoft Access on traditional Windows 10-based desktop personal computers. Instead of using visual means for creating database objects, students were prescribed to perform all database operations by manually entering SQL commands. However, the students were allowed to use Access's visual constructors to build forms for viewing and navigating through the contents of their databases in the read-only mode.

After switching to mobile-based learning, students started using the SQLite database engine on the college-owned Android-based smartphones for performing database tasks in a classroom. To access the engine, they used a front-end developed in-house for the course's internal educational purposes. This front-end meets the following essential requirements:

- support for different versions of the Android platform;
- ability to switch between the Russian and English languages of interface;
- the presence of a text-editing area for editing SQL statements;
- the presence of a grid-based area for viewing the contents of tables and results of the executed SQL statements in the read-only mode; and
- button-based menu for such operations as selecting and switching the database context, executing SQL statement from the text-editing area and navigating between records displayed in the grid-based area.

That is, as was the case with the previous-year lessons, at the new mobile-based lessons students, also, were not provided with visual means for creating database objects and had to do everything by manually typing SQL commands.

Letters	Range	(%)	Description of the grade
A	4.0	95-100	Excellent
A−	3.67	90-94	Excellent
B+	3.33	85-89	Good
B	3.0	80-84	Good
B−	2.67	75-79	Good
C+	2.33	70-74	Satisfactory
C	2.0	65-69	Satisfactory
C−	1.67	60-64	Satisfactory
D+	1.33	55-59	Satisfactory
D	1.0	50-54	Satisfactory
F	0	0-49	Unsatisfactory

Table I.
The grading system used in the college

3.5 The tasks

Table II contains the tasks assigned to the students in the database course. The scores that the students obtained at the database lessons came from doing these tasks. The teachers divided a task into two-three subtasks and each of these subtasks were expected to be completed within one lesson. If a student failed to complete the assignment during the classroom time he/she was allowed to continue the work on the assignment outside the classroom in his extracurricular time. In this case, he had to use his own mobile phone. It was often the case that the students worked on their assignments at home or in the college's library. For the reference purpose, when doing the tasks students were allowed to use their mobile device to access SQL-related Web resources.

The following criteria were used to assess the completeness of a separate task:

- the database contains all required data;
- the database uses more than one table;
- the table does not contain redundant data;
- each column has the most optimal data type;
- each column has an optimal name clearly reflecting its purpose;
- the table consists of less than ten columns;
- all columns in a table are logically connected, that is, describe the same entity;
- primary keys and indexes are used where necessary to ensure the uniqueness constraint;
- the relations between tables are defined using the primary and foreign keys; and
- the database demonstrates a reasonable performance.

Each of the above criteria was evaluated on a ten-point scale with 10 being the highest and 0 the lowest. Then these separate evaluations of each criterion were summed up to the overall score for the task, according to Table I, and entered in the college's electronic register for classes. It is from this register that the data on the students' academic performance was obtained for the purpose of the current study.

3.6 The quantitative aspects

The quantitative aspects included the data on the scores and the attendance rate demonstrated by the students from the target group in the database class. The data were processed with the help of Microsoft Excel spreadsheets.

To start with, the authors collected the data on the students' academic performance in the previous year's database course. With this purpose, the scores of the Groups C and D were taken and they were as in Tables III and IV. The former table provides the scores obtained by the students from the Group C while the latter table demonstrates the scores of the Group D. The last row in each of the tables displays an average score obtained by students on a specific task.

After that, the authors collected the data on the academic performance demonstrated by the students at the mobile-based database lessons during the study period. With this purpose, the scores obtained by the Groups A and B were taken. Then the scores of the Groups A, B, C and D were compared to each other to see the dynamics of change in the academic performance with respect to the previous year's results.

The next step was to compare these scores obtained by the Groups A and B to those obtained by the same groups in other disciplines of the computer science curriculum, such as

Task no.	Task description
1	Create a database of educational resources. The database is to include the following information about an educational resource: main URL mobile URL title academic subject to which the resource is dedicated description language of the content user's account credentials The database is to store information on at least ten educational resources
2	Create a database for storing data on students' academic performance. The database is to include the following information: student's full name student's home address student's phone student's birth date subjects scores teachers' full names size of scholarship The database is to include data at least on 15 students, five subjects and three teachers
3	Create a database for storing data on college's teachers. The database is to include the following information on a teacher: full name phone department position hourly rate number of lessons' hours home address resume The database is to include data at least on ten teachers, five positions and five subjects
4	Create a database for storing personal contacts. The database is to include the following information on a contact: full name home address phone birth date email Facebook account Twitter account personal website YouTube channel The database is to include at least ten contacts
5	Create a database for storing catalog of personal collection of DVD movies. The database is to include the following information about movies: title cast storyline director producer genre

(*continued*)

Table II.
The tasks assigned in the database course

Task no.	Task description
	rating country language release date running time budget production company The database is to include data at least on 20 movies, 10 production companies and 10 directors
6	Create a database for storing catalog of personal collection of books. The database is to include the following information about a book: title author genre ISBN-10 ISBN-15 language number of pages synopsis type of cover publisher weight dimension rating price The database is to include data at least on 20 titles, ten authors and ten publishers
7	Create a database for an online computer shop selling laptops. The database is to include the following information about computer: manufacturer model color weight operating system RAM screen size screen resolution CPU model CPU frequency Number of cores CPU architecture Video card Audio card Data storage Number of USB ports The database is to include information about at least 15 items
8	Create a database for college's football team. The database is to include the following information: coach's name coach's phone coach's address player's name

Table II. (*continued*)

Task no.	Task description
	player's address
	player's phone
	player's position on the pitch
	number of player's games in a specific season
	number of player's goals in a specific season
	calendar of the team's matches in a specific season
	tournament standings in a specific season
9	Create a classroom management database for managing data on students and their academic performance

Table II.

Student's no.	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
1	74	78	70	75	75	65	75	75	60
2	76	80	70	70	68	70	70	75	75
3	80	95	92	85	90	90	85	90	90
4	75	80	75	75	85	78	70	80	80
5	90	85	75	80	80	75	70	70	80
6	70	80	75	75	80	70	70	75	70
7	80	80	75	80	90	85	80	75	80
8	90	80	95	90	90	90	95	85	90
9	70	70	75	75	76	75	70	70	75
10	90	85	95	95	92	90	90	90	95
11	85	82	78	82	85	78	80	78	75
12	76	80	74	70	74	70	74	75	75
13	80	74	75	78	78	75	80	75	78
14	70	78	70	68	75	65	78	75	75
	79.00	*80.50*	*78.14*	*78.43*	*81.29*	*76.86*	*77.64*	*77.71*	*78.43*

Table III.
The previous-year's scores of the Group C

Student's no.	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
1	78	75	75	80	80	70	78	82	80
2	75	80	80	80	90	78	80	80	80
3	70	70	60	80	70	65	70	75	74
4	78	78	80	70	80	75	80	70	75
5	80	80	90	85	90	80	90	90	90
6	82	80	70	70	68	75	80	82	78
7	75	82	90	90	75	90	73	80	82
8	90	90	95	90	90	80	92	85	90
9	70	70	70	75	70	70	75	70	70
10	75	72	75	75	75	80	75	78	78
11	90	80	90	90	90	90	90	85	90
12	90	80	90	90	90	90	90	95	90
	79.42	*78.08*	*80.42*	*81.25*	*80.67*	*78.58*	*81.08*	*81.00*	*81.42*

Table IV.
The previous-year's scores of the Group D

computer graphics, programming, data structures and algorithms and computer algebra, which use desktop computers.

In the end, the authors collected the data on the previous year's attendance rate of the database lessons demonstrated by the Groups C and D. According to the college's register of classes the attendance rate of the previous year's database course was as given in Table V.

Then these data were compared to the attendance rate of the database lessons demonstrated in the study period by the Groups A and B.

3.7 The qualitative aspects

The qualitative aspects included the students' and the teachers' opinions concerning their attitude toward the use of mobile devices in the database classroom. To collect these opinions both the teachers and the students from the target group were asked to participate in an email questionnaire taken place in the last week of the study period. The questions were asked in Russian and were as follows:

Q1. Do you like the idea of using mobile devices in the database class?

Q2. Do you think that mobile-based learning has positively affected your interest in the subject?

Q3. What do you dislike about mobile-based learning?

4. Results

4.1 Academic performance

The data from the Tables III and IV show that the upper bound for the average scores at the previous year's database lessons of both groups was 81 and in the majority of cases, the average scores were even lower than this upper bound. In the same period, average scores per task in other lessons of the college's computer science curriculum attended by the same groups, such as computer programming and computer graphics, were about 83 with 84 being their upper bound. It made the database lessons have the lowest academic performance rate among computer science-related subjects.

The situation with the academic performance at the database lessons changed in the study period when the academic scores obtained by the students performing their database tasks on mobile devices were as given in the Tables VI and VII. The former table provides the scores obtained by the students from Group A while the latter table demonstrates the scores of Group B. The last row in each of the tables demonstrates an average score obtained by the students on a specific task.

As is seen from the tables above, the average academic scores per task are higher at the mobile-based lesson than it was at the previous year's lessons based on traditional desktop computers. Also, the average of all average scores per task at the database lessons is higher than in other disciplines of the college's computer science curriculum attended by the same groups, as is shown in Table VIII. The new upper bound for average scores per task became 88 while in these other disciplines it remained the same as in the previous year, that is 84. In

Table V.
The attendance rate of the previous year's database course

Group	January rate (%)	February rate (%)	March rate (%)	April rate (%)	May rate (%)
C	92	90	95	98	95
D	98	92	92	95	95

Student's no.	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
1	82	78	82	80	78	80	86	85	88
2	78	83	90	88	90	78	90	90	90
3	80	80	82	85	92	90	92	80	90
4	90	90	85	85	90	85	92	84	90
5	80	85	90	88	90	88	90	92	90
6	75	78	78	85	75	78	86	85	90
7	80	80	80	80	80	78	92	90	90
8	78	85	80	85	85	88	85	92	92
9	80	85	80	80	90	92	85	85	85
10	90	90	90	90	90	88	90	92	80
11	80	80	80	80	90	90	90	92	90
12	92	90	92	92	90	92	90	90	92
13	75	76	78	80	85	90	90	90	90
14	70	75	72	78	74	76	80	78	85
15	90	80	85	90	88	85	85	85	80
	81.55	*83.42*	*84.37*	*84.83*	*87.09*	*85.54*	*88.75*	*88.21*	*88.48*

Table VI.
Scores of the students of the group a in the study period

Student's no.	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
1	90	80	85	85	75	82	80	90	85
2	80	80	90	90	90	90	90	90	95
3	85	82	88	85	90	90	92	95	95
4	90	92	88	90	96	85	92	90	90
5	80	83	92	90	90	90	95	90	90
6	75	74	76	80	85	85	88	95	88
7	72	76	72	78	78	78	85	85	85
8	78	75	80	90	85	82	85	76	85
9	81	85	80	80	90	90	90	85	86
10	70	88	92	85	92	85	92	92	92
11	85	83	88	88	92	90	92	92	90
12	90	91	92	90	92	90	90	90	92
13	78	80	85	90	85	80	82	88	80
14	78	85	85	82	90	80	90	90	90
15	92	90	90	85	90	90	95	95	96
	81.54	*81.57*	*84.50*	*84.99*	*85.16*	*84.37*	*87.22*	*86.91*	*87.12*

Table VII.
Scores of the students of the Group B in the study period

Discipline	The average of the Group A	The average of the Group B
Databases	85.80	84.82
Computer Graphics	81.62	82.40
Programming	79.82	80.45
Data Structures	77.51	76.42
Computer Algebra	75.56	76.50

Table VIII.
The average of all average scores per task in computer science curriculum in the study period

addition, the closer to the end of the study period, the better became the average scores in both groups.

As is seen from Table VIII, during the study period the database lessons were the college's leader in the average academic performance per task, which was not the case in the previous academic year.

4.2 Attendance rate

The attendance rate of the database course during the study period was as given in Table IX.

4.3 The questionnaire

The questionnaire attracted 24 responses – 2 from the teachers and the other 22 from the students.

Answering *Q1*, all 24 respondents expressed their positive attitude toward using mobile technology in their database class.

Answering *Q2*, both teachers mentioned that, besides improving the academic performance statistics, mobile devices also brought with themselves other educational benefits such as stimulation of the students' motivation for learning and increase in the attractiveness of the lesson. Then, all 22 students reported to experience an increased interest in the deeper study of database practices and advanced SQL-related topics so as to be able to come up with the most optimized and efficient solution for the tasks targeting the mobile environment. Also, they reported that since the introduction of mobile-based learning they had started devoting more classroom and extracurricular time to the study of SQLite, mobile architecture and own database projects on their smartphones. In total, 14 students acknowledged that the mobile-based database lessons made them start considering a mobile device as a serious learning helper and prompted them to decrease the amount of time spent on using their mobile phones for the entertainment purpose.

Answering *Q3*, five students reported a small screen and the lack of traditional keyboard as minor obstacles in editing SQL expressions and viewing the contents of a database using the given front-end. This led to a big number of typographic errors in the process of editing SQL statements and eye strain, which, in turn, slightly decreased the students' productivity in the classroom.

5. Discussion

Like many other papers dedicated to using mobile technology in the academic environment, for example [13-19], the present article comes to the same conclusion of the usefulness of the mobile-based learning. However, at the same time, it differs in focusing exclusively on the college-level database course for IT students, describing the effective methodology of the introduction of mobile technology to the course and exploring the positive academic impact brought to the course by mobile devices. The results of the present article prove the correctness of the authors' hypothesis by demonstrating that the course indeed benefits from using mobile technology in its educational process. The present study's findings

Table IX.
The attendance rate of the database course in the study period

Group	January rate (%)	February rate (%)	March rate (%)	April rate (%)	May rate (%)
A	94	98	100	100	100
B	96	100	100	100	100

indicate that in the context of the course the role of mobile devices no longer can be that of a convenient means for passively viewing the learning content and taking the learning-related notes. Instead, there are ways of more advanced usage of mobile technology for creative technical tasks, such as, for example, development of classroom-assigned databases and editing their content. The significance of the study lies in its demonstration that with respect to the course mobile technology should now be treated not only as additional means for complimenting and expanding the use of traditional desktop computers but also as a full replacement for the latter. Actually, in most of the cases, for solving the problems assigned during class time in the course's classroom students do not need the whole computing power of desktop computers, and instead, can make the efficient use of the computing capabilities provided by mobile devices. Especially, as the computing capabilities of modern smartphones and tablets are enough to handle an IT classroom task of any level of complexity.

The present study's outcome also brings with itself some significant quantitative findings. If we take into consideration such indicator as the average of all average scores obtained by the students per task then, when compared to the previous academic year when the same lessons used traditional desktop computers, the following positive dynamics can be traced. In the class with the Russian language of instruction, the value of this indicator increased by 7 per cent, while in the class with the English language of instruction it increased by 4 per cent. Judging from this indicator alone, the database lessons had the highest rate of the academic performance among all subjects of the college's computer science curriculum taught to the students from the target group in the study period. The positive dynamics can also be observed in the change of other significant indicators such as the lowest average score per task and the highest average score per task. In the class with the Russian language of instruction, the lowest average score per task increased by 5 per cent and the highest average score per task increased by 7 per cent. In the class with the English language of instruction, the lowest average score per task increased by 3 per cent and the highest average score per task increased by 6 per cent.

By looking at the obtained data, one can also observe that the scores in the mobile-based database class tend to increase with each new task. It indicates that with each new lesson, the students get more accustomed to and experienced in the capabilities of a mobile device as the database development and management tool and it results in the improvement of the students' performance over the academic weeks with each new classroom assignment.

Alongside with the growth of the academic performance, the study saw significant improvements in the attendance of the database class as well. After two months, since its inception, the mobile-based approach had brought the attendance rate at the database class to 100 per cent in both groups.

The questionnaire also proved the study's hypothesis as all respondents expressed their positive attitude toward the introduction of mobile technology to the database course and the students' part of the respondents reported to experience an increased level of interest in the subject. This increased interest prompted them to learn more about the architecture of mobile devices and develop further their self-learning and research skills as they mostly tried to independently explore advanced topics not covered in the classroom.

Summarizing the quantitative data on the students' academic performance, the questionnaire's responses and the teachers' own observations and experience the authors determine the following five factors to be instrumental in causing the positive impact of mobile devices on the educational process in the database course:

(1) as a mobile device is a student's favorite environment in which he or she spends a significant amount of his or her time, then he or she naturally finds it attractive to remain within this environment even when completing the classroom assignments;

(2) the portable nature of a mobile device enables a student to keep working on his or her projects in any time and in any place without being restricted to the classroom; thus, increasing the productivity and flexibility of his or her work;

(3) the constant usage of a mobile device often stimulates a student to automate the process of collecting the data come from his or her daily activities by creating a compact database on his or her device. This, in turn, motivates him or her for doing well in the mobile-based database class;

(4) small screen sizes and relatively small amount of storage space in mobile devices make students consider the most compact and optimized way of implementing their database and in this process they start dedicating more time to the deeper study of such fundamental database aspects as data organization and normalization, maintaining correct relations between tables and optimization of SQL queries. This, in turn, deepens the students' level of expertise in the subject and develops their ability in the independent acquirement of knowledge; and

(5) from a student's standpoint a traditional desktop computer is associated with the old-fashioned database lessons while a mobile device represents the latest advances in information technologies.

Despite the overall positive results, the study's findings, however, have their own limitations. The number of students in the target group could have been larger, the study's timespan could have been longer and it could have been useful to test the students' learning outcome not only on Android-based mobile devices but also on those which run other mobile operating systems.

Another problem with the study's results is that the academic scores obtained by the students from both groups during the study period did not grow by the level of 10-15 per cent compared to the previous year as was initially expected. Such a situation can be explained by that aspect of mobile devices that the questionnaire's respondents found as negative, namely, small screen sizes and the lack of a traditional keyboard. Also, there exists a minor lag in the positive dynamics of the academic performance demonstrated by the English Group B. This lag can be explained by possible linguistic problems in understanding the lesson material in a foreign language and the fatigue caused by the fact that the database lesson was the group's last lesson of the day.

The authors argue that it is not the database class alone, which can use a mobile device as a full replacement for a desktop computer. The successful adoption of mobile technology by the database course can serve as a good example to other subjects from the college's curriculum as well. For example, it is possible to write and test JavaScript scripts on mobile devices themselves at Web programming lessons. Otherwise, a mobile device can be used at a programming class for accessing various online-based integrated programming environments without the need of using desktop computers at all.

6. Conclusion

The purpose of the present study was to test the authors' hypothesis of the positive educational impact, which mobile devices have on the college-level introductory database course. The study's materials were limited to the Android-based smartphones and its findings prove the correctness of the hypothesis. The authors verified that in the database class mobile phones can be used not only for the passive absorption of the learning material

but also as a full-featured means for creative technical tasks related to creating databases and editing their content. Moreover, this mobile-based approach helps the students to improve their academic performance and stimulates their interest in the subject. Mobile phones facilitate the academic process by allowing the students to do the classroom assignments on the same computing device that they use for their daily activities without being restricted to a fixed physical location inside the classroom as was the case with desktop computers. On the global scale, such creative usage of mobile devices in the academia can also contribute to causing the IT departments of industrial companies and public sector to rethink their view on the usage of mobile technology in their activity and start the process of the maximum shift toward the mobile infrastructure.

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Corresponding author
Spartak Sakibayev can be contacted at: sakibayev-zsu@bk.ru