The automated control of students achievements by using paper clicker Plickers

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Abstract – The article deals with the problem of organizing student achievement control using an online testing based on the Plickers software. It is established that schools’ teachers in Sumy region (Ukraine) and future mathematics teachers (Makarenko Sumy State Pedagogical University, Ukraine) are mostly unfamiliar with such technology. The usefulness of modernizing the content of educational curricular and master classes for working teachers to integrate the testing technology by using the mobile application Plickers into the educational process is confirmed. The article describes the process of preparation and experience of organizing an online testing of future mathematics teachers by using Plickers based on the study of the discipline "Mathematical logic and theory of algorithms". The advantages and disadvantages of using such a tool in the educational process are noted. The results of the effectiveness of the use of Plickers in the educational process are given.

Keywords – paper clicker; Plickers; online testing; student achievement; educational process

I. INTRODUCTION

Digital transformation of the educational sphere is necessary and irreversible process. This is emphasized in “Vision of Ukraine – 2030” by Ukrainian Institute of the Future [1], which correlates with the ideas of a perspective portrait of education of the 21st century – Education 4.0. It states the urgent need to revise the curricula of higher education institutions in order to integrate digital technologies into the educational process that meet the requirements of Industry 4.0. Outdated teaching methods, inaccessibility of digital technologies for the educational process have led to extremely low levels of digital literacy in all available segments of the state education system (preschool, primary, secondary, and higher). Therefore, the idea of introducing digital technologies, in particular, the means of automated control of students’ achievements is currently relevant.

The aim of the article is to describe the process of preparation and experience of organizing an online testing of future mathematics teachers by using Plickers, to prove the effectiveness of the use of Plickers in the educational process.

II. MOBILE LEARNING TECHNOLOGIES

One of the problems that teachers of Ukrainian educational institutions face is the lack of computers and limited access to computer classes. That is why the involvement of digital technologies in the educational process is “in bits and pieces”, is fragmented – they are used either by the teacher himself or by the student at home during independent work. At the same time, young people often use their own mobile devices not only to communicate on networks but also to support their own educational activities. Therefore, it is important to involve your own mobile devices (smartphones, tablets, netbooks, etc.) in the educational process. This approach is called BYOD (Bring Your Own Device). Implementation of the BYOD approach should be considered in the context of mobile learning. The authors have already addressed the problem of implementing the BYOD approach when using the GeoGebra cloud service in teaching natural sciences and mathematics [2].

At the same time, it is advisable to consider the use of mobile applications within the BYOD approach not only in teaching, but also from the positions of students’ achievement control. Let us note the mobile application Plickers in this context.

III. MOBILE APPLICATION Plickers

A. The analysis of current research on the problem of using the mobile application Plickers

When organizing digital exams, student response systems (online formative assessment, audience response systems) including Clickers, Plickers, Kahoot, and Socrative are becoming more popular recently. Plickers has a number of advantages over other applications of this type [3]. Let us note that Clickers costs around $ 1000-1500, each set containing 32 cartridges for 32 students. Plickers is an online software that works like a classroom response system, and it is free. This application is easy to use, does not need any hardware devices. Plickers require printed-paper cards and only one mobile phone or tablet to scan. Students' answers are automatically collected, stored, analyzed on the company website, and made available to the teacher.

The feasibility and effectiveness of using the Plickers mobile application is highlighted in the following findings.
J. R. De Thomas, V. López-Fernández, F. Llamas-Salguero, P. Martin-Lobo, and S. Pradas analyzed the relationship between educational achievement, engagement rate, and student creativity when using Plickers. They claim that active participation in the Plickers survey improves the quality of student knowledge [4].

T. A. Wood, K. Brown, and J. M. Grayson [5] examined the perception of Plickers by senior technology students as a method of achievement control. They found that this technology improves the audience, perceives the students as exciting, unusual and fast in terms of test results. S. Wuttiprom, K. Toeddhanya, A. Buachoom and K. Wuttisela [6] obtained similar results.

M. G. McCargo [7] examined the impact of the use of Plickers technology on the behavior of high school students and the perception of Plickers high school teachers as a socially sound method of combating student behavior. The author found out that Plickers provide every student with opportunities to respond, which an effective instruction strategy for promoting learning. Based on the results were mixed ratings of social validity from the teachers participating in this intervention.

A. Gürişik [8] analyzed the opinions of high school students regarding the use of Plickers and the problems that generated by students using this technology. It was found that Plickers makes a positive contribution to the lesson when it is used in education. The author approved that students find using Plickers in lessons enjoyable. They think that after the test, Plickers showing the correct and incorrect answers instantly has corrected their mistakes. Plickers enables a significant number of high school students to study more. A considerable number of high school students think that their success increases in Plickers tests.

O. Demirkan, A. Gürişik and O. Akin [9] explored teachers’ opinions regarding the use of Plickers in their professional activities. It was revealed that using Plickers saves time, shows the overall success of the class, increases class participation and competition, attracts students’ attention. It was determined that this program will enhance the motivation of students, students will enjoy it, students will get instant feedback, success and attendance will increase, and students will answer more questions. It was obtained that almost all of the teachers expressed that they would use Plickers in their class. It has been concluded that almost all of the teachers think that such trainings are very useful.

E. A. Michael, I. E. A. Ejeng, M. A. Udit, and M. M. Yunus [10] showed teachers’ opinions regarding the positive impact in assessing pupils’ understanding of reading comprehension classroom in a fun and stress-free way by using Plickers.

At the same time, there has been no systematic study of the use of the Plickers app in the educational process in Ukraine; in particular, in mathematics teaching, so scientific research in this area is relevant.

B. The organization of automated achievements control by using the mobile application Plickers

To start using the application, you need to register at http://plickers.com and enter the alphabetical list of the group (+ New Class).

Next, you must attach the appropriate tests to each group, that is, to add the tests to the so-called queue (Add to Queue). The queue is a series of questions to ask the group students at the next lesson. Once a question is asked, it is removed from the queue. Each time you need to update the queue of questions you need.

The teacher prints out the cards. Card layouts are available for download on the official site Help / Get Plickers Cards. Five different sets of cards are offered. Each card is unique and has its own number that corresponds to the student's number in the list. Therefore, the survey is personalized.

Each side of the card has a different answer – A, B, C, D (Fig.1). Cards can be used for every test, so it is worth printing them on paperboard.

![Figure 1. Students are answering the question](image1)

The teacher must download the Plickers app on his device. During the testing, the teacher should go to his own page and select a group and a test. At the same time, he should select Now Playing mode at the website on computer.

The teacher asks the question (the question is parallel displayed on the screen and on the mobile phone). The question can be selected from a mobile phone, the teacher does not have to be near the computer all the time, all control is from the phone (Fig.2).

![Figure 2. The teacher is reading the question](image2)
Students choose the answer by lifting the cards upwards. Using the mobile application, the teacher scans students' answers in real time and the results are stored in the database (Fig.3). The student can change his answer, but only the one that was at the time of scan will be counted.

The results are available both on the mobile app and on the site (on screen) for instant announcement and processing (Scoresheet) (Fig.4).

The teacher can also print the test results for both the whole group (Reports) (Fig.5) and for each student to work on mistakes (Students Reports or pre-clicking on the student's name). You can export the results table to an MS Excel file (Export Data to CSV).

C. Advantages and disadvantages of organizing achievements control by using the mobile application Plickers

Here are the organizational and methodological advantages and disadvantages of using the Plickers mobile application.

Organizational advantages:
- it is ease of use (simplicity);
- it is free;
- it does not demand student training to be used;
- it does not require students' devices, only the teacher’s mobile device is required;
- answer cards can be reused.

Among the organizational disadvantages of the Plickers app, the following can be distinguished taking into account the specific features of mathematics lessons:
- inability to insert formulas into question text or answers (only as drawings in the text of the question);
- there are only two types of closed-ended questions - single choice and multiply choice or true / false format;
- one test can have a maximum of five questions, so the teacher will need to create several tests and run them one by one. In this case, the results are provided for both a separate test and a series of tests;
- it requires a stable channel of access, both on the computer and on the mobile phone;
- it is not suitable for large student groups because the camera of the phone cannot fix all the answer cards.

Methodical advantages:
- the use of Plickers intensifies the learning process, brings elements of interactivity into the control process;
- it is a kind of fun for students;
- the teacher immediately sees who of the students answered correctly and who did not;
- students can change their answers, only the answer that was at the time of scanning is fixed;
- students do not see the answers of others;
- test results are instant, they are summarized in a table both for students of the whole group and for each student separately;
- for each student, you can print test results for each question to make corrections.

Methodological disadvantages:
- it cannot be employed in distance education, only face-to-face education.

The main ways to use the Plickers app in the classroom are a face-to-face testing at the end or at the beginning of the lesson, independent work as well.
IV. EXPERIMENTAL RESULTS

A. Research Questions

We needed to consider two problems: 1) whether the Plickers testing required more time than computer-based testing; 2) whether the computer testing is identical control form to the Plickers survey for evaluating student learning outcomes?

B. Methods

Until 2017, the educational process was provided for the organization of control of students' educational achievements in the form of computer testing. For each topic, 20 test questions were developed with four options for each. Computer testing was carried out at the end of each topic. The test was designed for 30 minutes of time.

With the advent of Plickers, the idea arose to introduce validation of academic achievement based on this tool because of its novelty as a means of control and interest in the technology of questioning by students.

Two years of experimentation, according to those teachers who used the tool, confirmed the possibility of its use, along with computer testing. However, the expediency and effectiveness of using Plickers required a pedagogical experiment.

After studying each topic (5 topics in total), students had two tests: computer-based testing and a Plickers survey. The questions were similar, but the order of the answer options, the order of the tasks themselves, and the numerical values of the output of the task conditions were changed.

We describe the results of the experiment on the example of the study of the discipline "Mathematical logic and theory of algorithms", where we studied:

- Topic 2. Propositional logic.
- Topic 4. First-order logic.
- Topic 5. Elements of Theory of computation.

C. Participants

The pedagogical experiment lasted for 2017-2019. It was attended by 101 persons – students of specialty 014 Secondary education (Mathematics and Computer Sciences).

D. Results

Statistical difference in time of control measures was checked according to Student’s t-test (Table I).

The Excel spreadsheet and the Data Analysis package were used to process the results (Table II).

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>28.2</td>
</tr>
<tr>
<td>Experimental</td>
<td>5</td>
</tr>
<tr>
<td>Hypothetical mean difference</td>
<td>0</td>
</tr>
<tr>
<td>df</td>
<td>4</td>
</tr>
<tr>
<td>t-statistics</td>
<td>3.638871</td>
</tr>
<tr>
<td>P(T&lt;=t) one-sample</td>
<td>0.010993</td>
</tr>
<tr>
<td>t critical one-sample</td>
<td>2.131847</td>
</tr>
<tr>
<td>P(T&lt;=t) two-sample</td>
<td>0.021987</td>
</tr>
<tr>
<td>t critical two-sample</td>
<td>2.776445</td>
</tr>
</tbody>
</table>

The results confirm a statistical difference between the average time spent on computer testing (28.2 minutes) and the Plickers survey (23.4 minutes).

The impact of the control form on learning achievements was tested according to McNamara's test.

Controls were assumed to be based on the same material: first, students were computer-tested, then the same set of questions and answers was conducted using Plickers. Based on the results, students were divided into two categories: mastered  – not mastered. The first group included students who answered correctly 13 or more questions. Other students were assigned to the second group.

The results of the double control of students' achievements represent the measurement on the scale "Yes – No". The results are presented in Table III.

<table>
<thead>
<tr>
<th>Results using Plickers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer test results</td>
</tr>
<tr>
<td>mastered</td>
</tr>
<tr>
<td>not mastered</td>
</tr>
<tr>
<td>a</td>
</tr>
<tr>
<td>c</td>
</tr>
<tr>
<td>a+c</td>
</tr>
</tbody>
</table>

Under these conditions, McNamara test may be used to identify the significance of the difference in student distribution by the level of academic achievement.

Hypothesis $H_0$ is tested: the control form does not impact the distribution of students by the level of their academic achievement. Then the alternative hypothesis $H_1$ is "the distribution of students by the level of their academic achievement depends on the chosen control form". Under these conditions, McNamara's two-sided test is used. For $n=b+c>20$ the value of the statistics $T_{exp}$ is calculated by the formula $T_{exp} = \frac{(b-c)^2}{b+c}$. At the significance level $\alpha = 0.05$ we have a critical value of $T_{crit}=3.84$. 

TABLE I. AVERAGE TIME FOR TASKS (MIN.)

<table>
<thead>
<tr>
<th></th>
<th>Topic 1</th>
<th>Topic 2</th>
<th>Topic 3</th>
<th>Topic 4</th>
<th>Topic 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer testing</td>
<td>30</td>
<td>26</td>
<td>30</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>Plickers</td>
<td>21</td>
<td>24</td>
<td>24</td>
<td>25</td>
<td>23</td>
</tr>
</tbody>
</table>
Table IV shows the results for 2017, 2018, 2019 for topic 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>$T_{exp}$</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>51</td>
<td>14</td>
<td>25</td>
<td>11</td>
<td>3.10</td>
<td>$H_0$ is accepted</td>
</tr>
<tr>
<td>2018</td>
<td>57</td>
<td>10</td>
<td>16</td>
<td>18</td>
<td>1.38</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>62</td>
<td>11</td>
<td>16</td>
<td>12</td>
<td>0.92</td>
<td></td>
</tr>
</tbody>
</table>

Taking into account that $T_{exp} < T_{crit}$ for each year and each topic, we had no reason to reject the $H_0$ hypothesis at the significance level $\alpha = 0.05$.

**E. Discussion**

Establishing statistical difference in time of control measures we found out a smaller gap in the mean time for topics 2 and 4 is evident, when the theoretical knowledge is largely tested. A larger gap in average time for topics 1 and 3 when testing skills to solve practical tasks. Results on topic 5 are mixed.

The shortening of the average time in the Plickers survey is explained by the peculiarity of using this technology – fixing of students’ answers is instantaneous, as is the change of questions on the screen, while in computer testing each student at his own pace answers the questions.

When interviewing with Plickers, students answer in their own pace. Students with low educational achievements or a phlegmatic or melancholy psychotype are guided by the response rate of students with high and intermediate educational achievements and often thoughtlessly answered.

In computer testing, there have been cases where time is running out and the student has not yet answered all of the test questions. With the use of the Plickers technology, such situation is impossible.

The average time of computer-based testing is largely determined by the pace of completion of the tasks of the majority, i.e. students with average academic achievement. The average interview time with Plickers depends on the pace of task solving for students with high levels of academic achievement.

Studying the impact of the control form on learning achievements we found out that the control form does not impact the distribution of students by their level of academic achievements.

The generalization of the other scientists’ findings confirmed that similar studies were not conducted, hypotheses of this type were not put forward.

Taking into account the statistical analysis of the results, *Plickers* should be recommended as an alternative to computer-based testing, because it (with prior mastery of organization technology and testing) takes less time and results are adequate to students’ achievements.

The prospects of further research are seen in the use of *Plickers* as a means of control future teachers’ educational achievements, but also as an object of study in order to implement this technology in their future professional activities.

**REFERENCES**