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SHORT PAPER

Combined Teaching of Mathematics with the Halomda Platform

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ABSTRACT

Distance learning is very challenging for both teachers and students. Technology can help educators in combined teaching, which means combining traditional educational methods with active learning. The Halomda educational platform provides improving students' active learning due to better students' engagement. This enhances students' performance as well as the ability to solve mathematics problems. In this paper, we share our experience of how using the Halomda system for combined teaching in the "differential equations" course significantly improves student learning outcomes.

KEYWORDS

combined teaching, Halomda platform, distance learning, blended learning

1 INTRODUCTION

The pandemic years have forced teachers at schools and universities to look for new tools and methods for teaching. The teaching of mathematics is no exception, and there is a search for new teaching methods, including those associated with the development of new technologies. As it is outlined in [1], "In addition to the common questions on how to deliver teaching at distance, mathematics teachers had specific needs—e.g., to integrate mathematical tools into their teaching—and specific views on the use of digital technology."

Distance learning can be synchronous, i.e., the teacher delivers his lectures in real time, or asynchronous, in which he records the lecture so that students can watch it at their convenience, or both. Distance learning employing various learning systems has emerged. In Israel, the Zoom system is widely used, offering the teacher and student various tools, including an electronic whiteboard and the ability to view the lesson after classes. However, distance learning deprives students of the opportunity for live communication outside of class, which is very important when building social connections between students. Nowadays, we spend a lot of time in the virtual world, and the further we go, the more we lack live communication.

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Some authors [2] considered distance learning to be a more teacher-centred approach to learning. One of the solutions to overcome the destruction of interpersonal connections is hybrid (blended) learning, which includes not only group learning at the classroom and distance learning at home, but also supplemented by an asynchronous form of learning, when the student independently works on the proposed tasks and manages his time allotted for solving the set task, i.e., this tends to be more of a student-centred approach to learning [2], [3].

One of the advantages of distance learning is its convenience, as many of the technologies are easily accessible from home. Many forms of distance learning give students the opportunity to participate in classes at any time on an individual basis due to the flexibility of distance learning. This type of education is quite affordable, as many forms of distance learning are not expensive [4].

What makes asynchronous learning different is that students are required not only to solve a list of tasks, but also to go through various activities that will help them reinforce the material they have learned in a face-to-face meeting at the classroom.

In blended learning, especially when evening students experience a lack of time for face-to-face instruction, the instructor needs a tool to reinforce what they have learned from homework assignments.

According to [5], *combined teaching* methods include traditional teaching plus active learning (AL). AL is "highly influenced by class and preparation times, administration effort, and availability of resources" [6]. AL is very important in the practice of distance learning. In order to stimulate students to actively learn during distance learning, we suggest using digital technology. Several authors [7], [8] outlined that using technology in teaching mathematics has resulted in better student engagement and performance, enhances students' ability to solve mathematics problems, and increases their levels of mathematics self-efficacy. The technology can be used in different models [9], for example: to support working with multiple representations; to support discovery learning; to support individual learning; to support practicing.

The Halomda platform offers the opportunity to enhance active student learning during distance learning in all the models mentioned above. The system provides various modes of training, acquirement, and testing of the learned material. Last but not the least, cheating is one of the problems of distance learning, and the Halomda platform suggests its own tools to prevent cheating [10].

In this paper, we posed two research questions:

RQ 1: To what extent can combined teaching affect the students' results during the distance learning?

RQ 2: To what extent can using the Halomda platform improve students' outcomes?

2 POSSIBILITIES OF THE HALOMDA PLATFORM IN TEACHING MATHEMATICS

Any lesson requires preparation. Preparing a lesson in the Halomda system involves the development of a series of tasks that will be offered to the students as a means of e-assessment (more details about the Halomda platform can be found in [11]). Many of the existing commercial e-assessment systems use the simple multiple-choice method of assessment that requires the student to find the correct final answer. The Halomda system employs two approaches of e-assessment: simple multiple choice and extended multiple choice, when the complete solution of the problem is divided into several steps and the student needs to find the answer to each step of the solution.

We conducted an experiment while teaching two courses: *Statistics* and *Differential equations* for students—future teachers in the Kaye College of Education (Israel). In this paper, we describe our research on teaching the course *Differential equations*.

To develop a lesson in the Halomda system on a particular topic, the teacher should break the solution of the problem into smaller subtopics so that the correctness of each step of the solution can be checked. Such a division of the solution into steps also enables the teacher to control the correctness of the solution algorithm and to identify possible mistakes of the student.

The system offers not only solving control questions, but also studying theoretical material by systematic exposure to typical examples, as well as training exercises. These are the parts of the course (or a particular laboratory work) that are most interesting and creatively challenging for the developer.

2.1 The studying phase

Consider the stage of studying, or rather, repeating the material passed by the student to solve the tasks of the assignment. First, we offer a student the solution plan for this type of problem.

Let's look at an example of solving differential equation requiring finding the integrating multiplier:

$$y' = \frac{x^2 + y}{x} \tag{1}$$

In the Halomda platform, the task is presented in the following manner:

> Problem 1
>
> Solve the differential equation: $y' = \frac{x^2 + y}{x}$

During the Learning mode, the student can see the solution plan in a form of series of steps (in parentheses is given the mark in percent for each solution step):

- reduction of the equation to the form:

  $$y' + a(x) \cdot y = b(x),$$

  provided that the functions $a(x)$, $b(x)$ are differentiable on the given region of determination. In our case, for all $\mathbb{R}$; (**15%**)
- looking for the integrating factor in the form $e^{A(x)}$, so that if we multiply both parts of the equation, we get the formula for the derivative of two functions in the left part; (**30%)**
- reducing the equation to a form suitable for integration: $(y \cdot e^{A(x)})' = b(x) \cdot e^{A(x)}$; **(15%)**
- integrate both parts of the equation. (**40%**)

2.2 The self-monitoring phase

Leaving aside the discussion of the solution above, let's move to the self-monitoring phase of the learner.

A step-by-step check on the solution of the equation. At each stage, several options of intermediate answers are offered. The student should compare his answer to the presented options and identify the recommended one (choose during in "exam" mode). Note that it is desirable that the wrong answers have similar form to the correct ones (usually differing in the values of numerical parameters). Note that in this paper, the correct answer will always come first, while the system chooses the sequence of answers randomly.

- **Step one:** equation conversion.
  Question: What is the equation template after converting the original equation (15%)?
  The system offers 4 options for the reduced equation (Figure 1):
  - $y' - \frac{y}{x} = x$
  - $y' + \frac{y}{x} = x^2$
  - $y' = x + \frac{y}{x}$
  - $y' - x = \frac{y}{x}$

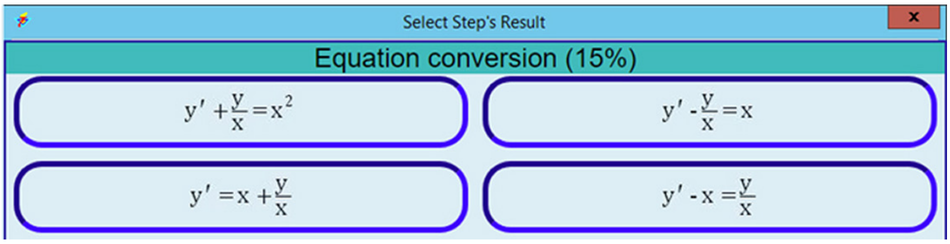

Fig. 1. First step of the solution

- **The second step:** involves not only checking the correctness of the integral multiplier, but also knowledge the properties of the logarithmic and exponential functions.
  Question: Find the integral multiplier for the given equation (30%).
  Four opportunities are shown in Figure 2.
  - $\frac{1}{x}$
  - $-\frac{1}{x}$
  - $e^{\ln x}$
  - $e^{-\ln x}$

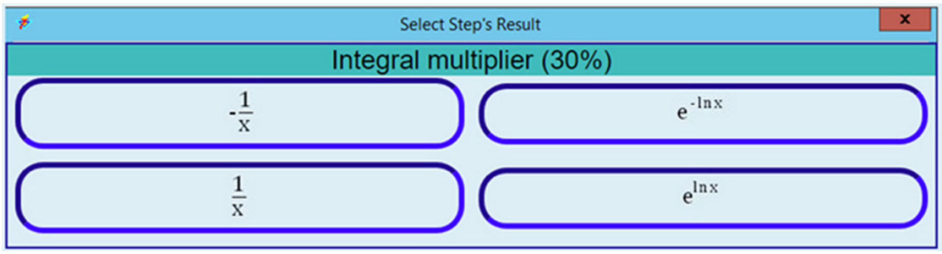

Fig. 2. Second step of the solution

- **Step 3:** testing student's knowledge and ability to reduce the original equation to the equation suitable for integration.
  Question: Which equation should be integrated (15%)?
  Possible answers are given in Figure 3.
  - $\left(\frac{y}{x}\right)' = 1$
  - $\left(-\frac{y}{x}\right)' = 1$
  - $\left(\frac{y}{x}\right)' = -1$
  - $\left(\frac{y}{e^{\ln x}}\right)' = -1$

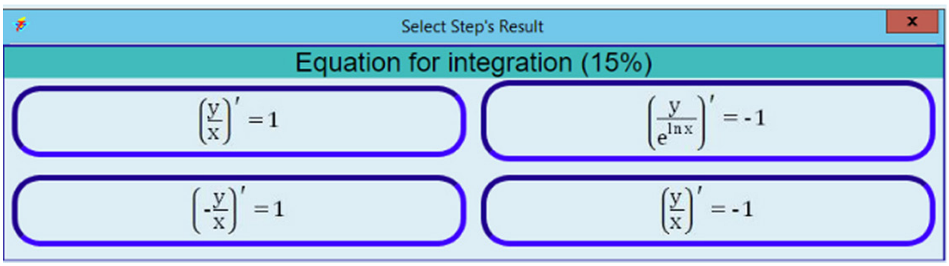

Fig. 3. Third step of the solution

- **Step 4 (the final step):** checking the result.
  Question: Which family of functions is the solution to the original differential equation (40%)?
  Possible equations are shown in Figure 4.
  - $y = x^2 + Cx$
  - $y = -x^2 - Cx$
  - $y = -x^2 + Cx$
  - $y = -x \cdot e^{\ln x} + Ce^{\ln x}$

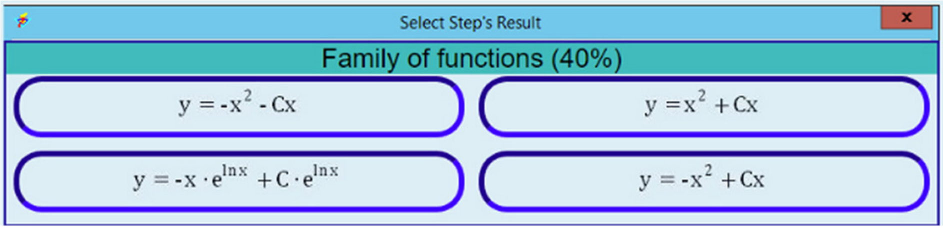

Fig. 4. Fourth step of the solution

It should be noted that similar test work can also be prepared in the Moodle system, but this will require much more effort at the development stage (because of the requirements to be familiar with programming languages and the lack of a suitable test editor—unlike the Halomda system that includes graphical Task Editor).

3 ANALYSIS OF THE RESULTS OF USING THE HALOMDA SYSTEM

To analyze the results, we turned to data for 2020 and 2021 compared to the current year 2022. It should be remembered that 2020 was the year of the pandemic and global student learning from home. This affected a slight reduction in the requirements for students, like extra trials of exams, expanded lists of formulas allowed for use in exams, etc. It can be noted that 2021 was similar to the current year 2022 in terms of learning conditions and tests, both on campus (exams) and remotely (homework). In 2020 and 2021, students completed their homework in the Moodle system, and in 2022, they used the Halomda platform to prepare and complete the homework.

In 2020, 13 students studied at the mathematics department. The average final score of the group was 75.23 points, with an average statistical error of 18.78. The final grade was calculated by the formula: test 0.8+task 0.2 (80% of the exam grade and 20% of the home task). The results for 2020 are reflected in Figure 5.

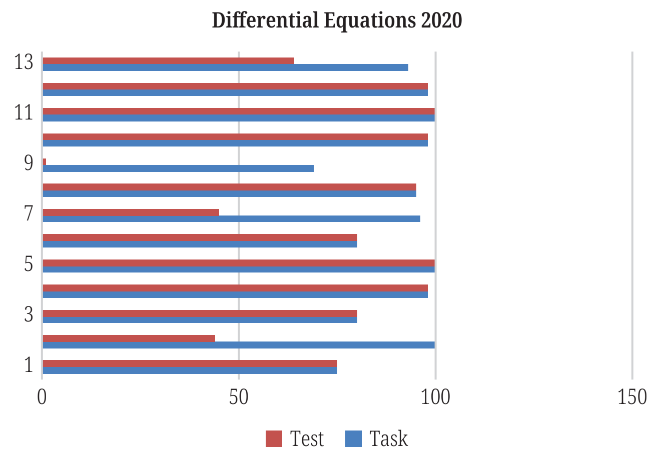

Fig. 5. Students' results for 2020

In 2021, there were 15 students in the mathematics department. The average final score of the group was 77.41 points, with an average statistical error of 17.05. The final score was calculated using the same formula as the previous year. The results for 2020 can be seen in Figure 6.

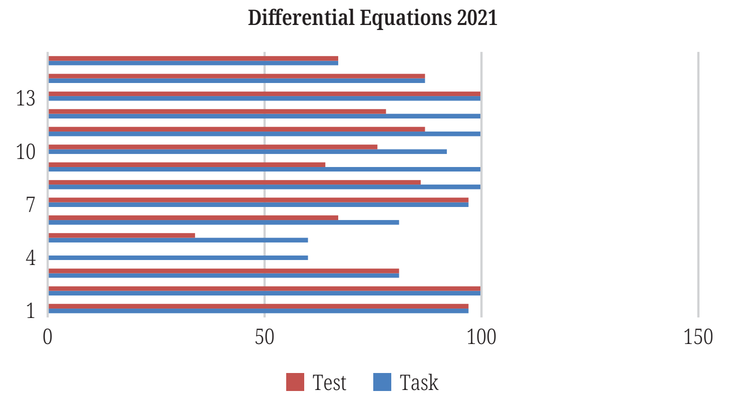

Fig. 6. Students results for 2021

From the data presented above (to a certain degree of approximation) it can be concluded that combined work on campus and at home results as good student outcomes (RQ 1). In addition, it should be noted that the homework was conducted as a test work in the Moodle system and did not give an opportunity to analyze at what stage students had difficulties, and which subsections of the tested topic were not worked out sufficiently.

In 2022, there were 10 math students in the group. The average final score of the group was 86.86 points, with an average statistical error of 14.061. The final grade was calculated using the same formula as in previous years (see Figure 7).

4 WORKING EXAMPLES

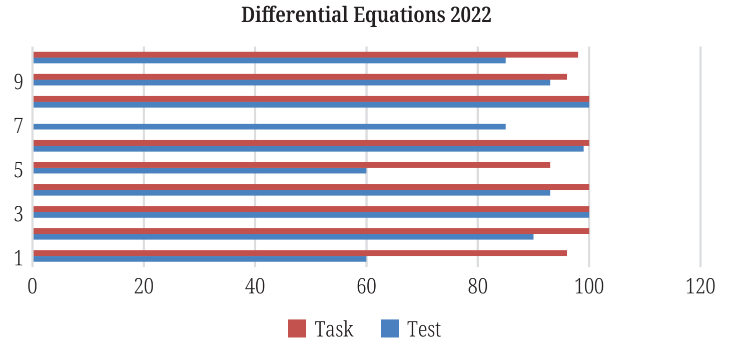

Fig. 7. Students results for 2022

Using the Halomda system, students had the opportunity to review what they had learned, to have more practice, and only then complete the test portion before completing the test.

It can be stated that the result has improved, but the most important thing, from our point of view, is that the statistical mean error of the results has decreased (RQ 2). The error decreased from 17–18 to 14 units.

5 CONCLUSION

Distance learning still needs to be studied in detail, although, to date, there are many studies that confirm the advantage of this form of learning. But also, quite a few studies show the disadvantages of using distance learning as the only form of student learning. In this article, we tried to investigate the combined forms. The Halomda system was used as a supplement to the main, frontal classes. Students had the opportunity after the main lessons in an interactive mode to repeat the material, practice solving test problems and check the assimilation of what has been learned.

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