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Research Article

SELF-STUDY OPPORTUNITIES FOR STUDENTS TO SOLVE LINEAR EQUATIONS THROUGH MOBILE LEARNING WITH MICROSOFT MATH SOLVER APPLICATION ON SMARTPHONES

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ABSTRACT

Mobile learning refers to the process of learning using mobile devices such as smartphones, tablets, and other handheld devices to provide educational content, study materials, and learning experiences for users anytime and anywhere, thanks to internet connectivity. With the advancement of the Internet, smartphones have evolved into a ubiquitous cultural instrument on a global scale. Mobile learning is suitable for developing self-management and self-study competencies, one of the three general competencies in the Vietnam 2018 General Education Curriculum. We have developed self-study activities for students by leveraging the Microsoft Math Solver application, an AI app predating AI Chatboxes, for learning linear equations for 8th graders. The results of this study confirm the effectiveness of self-study through the selected mobile learning app. Students are active in self-study at home as required in the 2018 Mathematics Curriculum. Teachers can rely on what students study at home to consolidate this knowledge in the classroom.

Keywords: linear equations; Microsoft Math Solver; mobile learning; self-study; smartphone

1. Introduction

The proliferation of mobile devices and technologies in schools has inspired educational researchers to introduce the term 'mobile learning' (or m-learning) to transcend the boundaries of traditional pedagogical methods (Tang et al., 2023). Mobile learning involves using smartphones and other mobile devices to access educational materials anytime and anywhere through the Internet. Over the past decade, this form of learning through smartphones has become increasingly popular due to their features, such as convenient access to educational resources, portability enabling learning at any time and place, compatibility with diverse multimedia teaching formats, facilitation of immediate

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feedback on learner interactions with study materials, personalized learning experiences, the establishment of a conducive environment for social interaction, and the capability to support offline learning. Although smartphone usage is widespread among learners, not many schools implement mobile learning in the teaching and learning process (Pranama 2018; Le & Tran 2021). Trinh (2014) argues that learning in a mobile learning environment can support self-study, such as enhancing the learner's autonomy, facilitating learning and assessment both inside and outside the classroom, and adopting new forms of learning as science and technology evolve. Furthermore, mobile learning outside the classroom can leverage an incredibly rich source of resources through internet connectivity and AI software that can help students access these resources. Alongside the irreversible trend of the widespread use of smartphones, concerns about the downsides of these devices for students have been raised, particularly in terms of their impact on student concentration if not well managed.

1.1. Self-study and self-study competency

Self-study is the process of autonomously acquiring knowledge by assimilating, processing, and transforming external information into internal understanding (Dao, 2018; Nguyen, 200). Self-study competency is an individual's ability to independently and effectively tackle challenges by applying learned knowledge to real-life situations and activities. This competency enables learners to explore the world around them, adapt to it, and transform it to achieve learning goals and individual development (Ministry of Education and Training – MOET, 2018a; Nguyen, 2001).

1.2. Linear equations in eighth-grade mathematics program

MOET (2018b) stipulates two requirements for teaching this content: understanding the concept of linear equations and how to solve them (content 1) and being able to solve practical problems related to linear equations (content 2). There are various textbooks, and teachers can choose or design teaching materials to meet the requirements. For example, with the second requirement, teachers can choose problems with practical or interdisciplinary elements and implement teaching following the mathematical modeling process consisting of three steps as outlined in the 8th-grade mathematics textbook by Ha et al. (2023): (1) Formulate the equation (including selecting the unknown and setting appropriate conditions for it, representing the unknown quantity in terms of the unknown and known quantities, formulating equations representing the relationships between quantities); (2) Solve the equation; and (3) Answer (including checking which solutions satisfy the conditions of the unknown in the equation, which ones do not, and then drawing conclusions). In the self-study process, we will arrange for students to independently generalize how to solve a linear equation using the Microsoft Math Solver application (MMS) on their smartphones (content 1). Additionally, students can also search for and

independently solve real-world problems suggested on websites linked to this application (content 2).

1.3. Microsoft Math Solver application on smartphones

Created by Microsoft, MMS was officially released in 2019. This mobile application is compatible with both iOS and Android platforms, utilizing artificial intelligence (AI) technology to assist users in solving mathematical problems. MMS is free, user-friendly, ad-free, and supports multiple languages, including Vietnamese. The application enables users to capture images of hand-written or printed mathematical problems, offering step-by-step solutions accompanied by explanations. This feature is particularly beneficial for students seeking assistance in solving mathematical problems during the learning process.

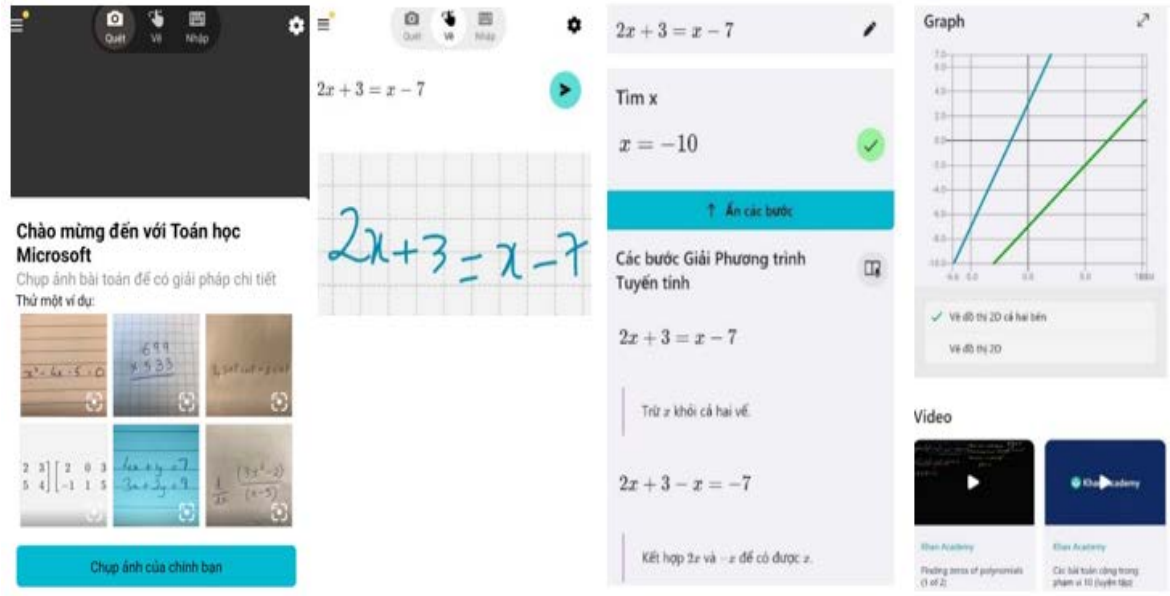


Figure 1. *The interface of MMS on a smartphone*

This application allows users to visualize algebraic expressions and graphs of equations or functions. Additionally, it suggests and enables students to connect with other popular math education websites.

2. This study

2.1. Research questions

The learning process was applied to teach both content 1 and 2. The goal is to examine the impact of the self-study stage at home using MMS on students' learning for the selected content, both qualitatively and quantitatively. The research aims to address the following questions:

Research question 1: Is there a significant difference in learning outcomes between students learning through mobile learning with MMS (experimental group) and students learning through traditional methods (control group)?

Research question 2: What do students discover during the self-study process with MMS?

2.2. Mobile learning with MMS

Mobile learning was organized for students using the following steps:

Step 1. Teachers assign tasks and instruct students to install and use the MMS application on their smartphones. Teachers can guide these tasks online and request students to borrow their parents' smartphones. Teachers communicate with students' parents to explain and seek permission for students to participate in mobile learning.

Step 2. Students engage in self-study at home with the assistance of the MMS application on their smartphones. This step consists of three stages: Stage 1 – individual work on content 1; Stage 2 – group work on content 1; Stage 3 – group work on content 2.

Step 3. Students report their self-study results, and the teacher consolidates the knowledge.

2.3. Participants

An experimental group and a control group were conveniently selected from 8th-grade classes at Nguyen Tri Phuong Middle School, Ho Chi Minh City, for the academic year of 2021-2022. The experimental group was class 8/4 with 42 students. The control group was class 8/3 with 42 students. The experimental group followed a teaching process with a self-study phase, while the control group learned with traditional methods. The experiment took place over two weeks, from October 4, 2021, to October 18, 2021. During this Covid-19 pandemic period, teaching occurred online using Google's free platforms, Google Meet, and Google Classroom.

Firstly, we analyzed the academic results of these groups based on the mathematics scores from the previous year (2020-2021). Using Excel, we conducted a paired hypothesis test:

H0: The average math scores from the previous year of the two groups are equal;

H1: The average math scores from the previous year of the two groups are different.

Testing the equality of variances between the two groups shows a P-value = 0.07> 0.05. Thus, it is possible to accept that these two groups have equal variances.

t-Test: Two-Sample Assuming Equal Variances

	Lớp 8/3	*Lớp 8/4*
Mean	7.061904762	6.992857143
Variance	3.14583043	1.96945993
Observations	42	42
Pooled Variance	2.55764518	
Hypothesized Mean Difference	0	
df	82	
t Stat	0.197850981	
P(T<=t) one-tail	0.421825656	
t Critical one-tail	1.663649184	
P(T<=t) two-tail	0.843651311	
t Critical two-tail	1.989318557	

Figure 2. *Statistical testing for the equivalence of the two groups*

With a p-value = 0.599 significantly greater than 0.05, the null hypothesis H0 is accepted. Therefore, it can be concluded that the academic performance in mathematics of the experimental group and the control group before the experiment is considered equivalent.

2.4. Instruments

2.4.1. Quantitative data

After the experiment, students from the experimental group and the control group take a 30-minute essay test. The test was designed based on the requirements in the Mathematics Curriculum. The test for the experimental group and the control group is as follows:

Question 1(2.0 points). Fill in the blanks with appropriate terms:

a) The equation has the form……, with a and b being two given numbers, and a ≠ 0 is called a linear equation.

b) If an equation is a linear equation, with the form ax + b = 0 and a ≠ 0, then it always has a unique solution, that is……..

Question 2. (4.0 points). Solve the following equations:

a) $2x+5=3(x-1)+2$ …… ……	b) $(x-1)^2=4(2x-1)+1$ …… ……

Question 3. (4.0 points). A car travels from A to B with an average speed of 40 km/h, then returns from B to A with an average speed of 50 km/h. Therefore, the time to return is 30 minutes less than the time to go. Calculate the distance from A to B.

2.4.2. Qualitative data

To assess the effectiveness of the self-study of students in the experimental group using MMS on smartphones, we qualitatively analyzed the worksheets given to students in step 2 of the mobile learning process. With Worksheet 1, students independently explored how to solve equations that can be transformed into linear equations and began to connect with the general method of solving a linear equation. Students collaborated in groups in Worksheet 2 to investigate, agree on ideas, and present knowledge about converting certain equations into linear equations. In Worksheet 3, student groups independently explored how to solve a real-world problem by formulating an equation, transforming it into a linear equation, solving it, and providing answers. These tasks were developed based on the two curriculum requirements mentioned at the beginning of section 1.2.

Individual work on content 1 - Worksheet 1:

Given the following equations:

$2x+5=3(x-1)+2$ (1) $(x-1)^2+x+1=x(x-2)+4$ (2)

$\frac{3x-2}{4}=x-1$ (3) $\frac{-9+x}{2x+1}=\frac{3}{x+1}$ (4)

a) Using MMS on a smartphone, find the solutions to the given equations.
b) Using MMS on a smartphone, present the solution steps for each equation.
c) Using MMS on a smartphone, provide two similar exercises and give detailed solutions for those exercises.
d) Based on the examples above, describe how to solve an equation that can be transformed into the form $ax + b = 0$.

Group work on content 1 - Worksheet 2:

Recall the definition: A linear equation in the variable x is an equation of the form $ax + b = 0$, where a, b are given numbers, and $a \neq 0$.
Illustrative example: $3x + 1 = 0$ is a linear equation in the variable x with $a = 3$ and $b = 1$.
Given the following equations:

$2x+5=3(x-1)+2$ (1) $\quad$ $(x-1)^2+x+1=x(x-2)+4$ (2)

$\frac{3x-2}{4}=x-1$ (3) $\quad$ $\frac{-9+x}{2x+1}=\frac{3}{x+1}$ (4)

$x^3-x(x+1)=(x-2)(x+1)-2$ (5) $\quad$ $(2x-1)^2+13=4x(x+1)+3$ (6)

a) Which equation can be reduced to the form of a linear equation? Why?
b) Using MMS and the textbook, present the knowledge that your group knows about equations in general and linear equations in particular.

Group work on content 2 - Worksheet 3:

a) Solve problems 1 and 2
Problem 1. This year, the mother's age is three times Phuong's age. Phuong calculates that in 13 years, the mother's age will be only twice Phuong's age. How old is Phuong this year?
Problem 2. A canoe travels downstream from pier A to pier B in 4 hours and upstream from pier B to pier A in 5 hours. Calculate the distance between piers A and B, knowing that the water current speed is 2 km/h. Solve the two problems following the steps as suggested in the worksheet.
b) Present a general method for solving real-world problems by setting up equations.
c) Using MMS, the group should search for two real-world problems and present detailed solutions for those problems using the general solving method mentioned.

2.5. Results and Discussion

2.5.1. Quantitative result

To answer research question 1, we analyzed test scores between the experimental group and the control group to test the following hypotheses:

H0: After the intervention, the average test score of the experimental group is equal to the control group.

H1: After the intervention, the average test score of the experimental group is higher than the control group.

Testing the equality of variances between the two groups shows a P-value = 0.2> 0.05. Thus, it is possible to accept that these two groups have equal variances.

t-Test: Two-Sample Assuming Equal Variances		
	Control group	*Experimental group*
Mean	6.928571429	7.797619048
Variance	3.787456446	2.915360046
Observations	42	42
Pooled Variance	3.351408246	
Hypothesized Mean Difference	0	
df	82	
t Stat	-2.175402155	
P(T<=t) one-tail	0.016239656	
t Critical one-tail	1.663649184	
P(T<=t) two-tail	0.032479313	
t Critical two-tail	1.989318557	

Figure 3. *Statistical testing on the output scores of the two groups*

With a P-value = 0.032 < 0.05, the null hypothesis (H0) is rejected. Since the average score of the experimental group (7.8) is higher than the average score of the control group (6.93), the alternative hypothesis (H1) is accepted. The results indicate the effectiveness of the mobile learning process with MMS-supported self-study.

2.5.2. Qualitative analysis

The responses in the worksheets created during the self-study stage of the experimental group provide data for research question 2.

a. Stage 1 - Individual work on content 1

The content of worksheet 1 aims at students using the MMS application on their smartphones to understand how to solve equations that can be transformed into linear equations. The time allocated for this worksheet was four days, and it was an individual task. The students engaged in mobile learning and responded to the worksheets in Word files, submitting their assignments through Google Classroom. The results show that all students were able to use the MMS application to find solutions and understand how to solve the four equations provided in worksheet 1. For instance, one student (S19) answered the equation (4) as follows:

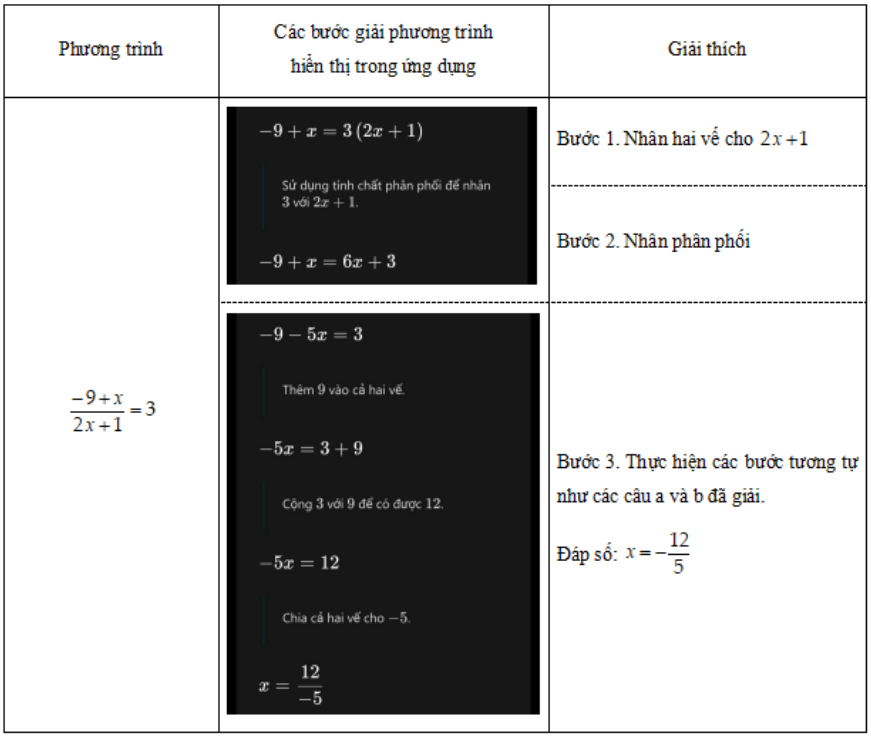
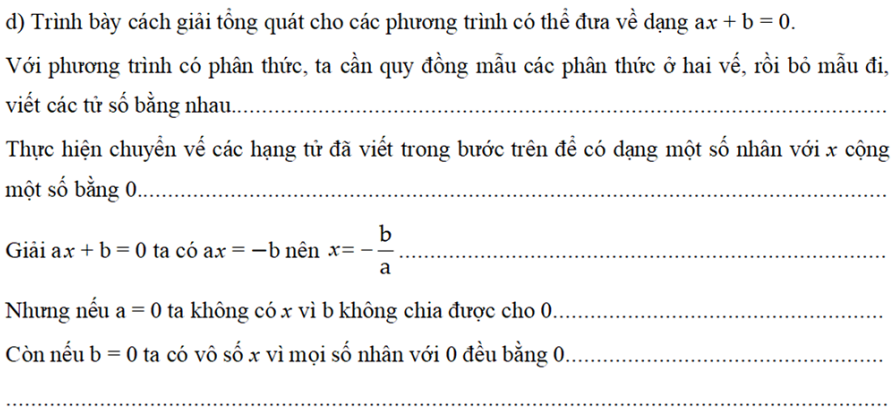


Figure 4. *The answer of student 19*

For question *d* (describe how to solve an equation that can be transformed into the form ax + b = 0), only two students did not respond and there were 14 correct answers (out of 40 responses). For example, the solution provided by S19 is as follows:


d) Trình bày cách giải tổng quát cho các phương trình có thể đưa về dạng $ax + b = 0$.

Với phương trình có phân thức, ta cần quy đồng mẫu các phân thức ở hai vế, rồi bỏ mẫu đi, viết các tử số bằng nhau.....

Thực hiện chuyển về các hạng tử đã viết trong bước trên để có dạng một số nhân với x cộng một số bằng 0.....

Giải $ax + b = 0$ ta có $ax = -b$ nên $x = -\frac{b}{a}$.....

Nhưng nếu $a = 0$ ta không có x vì b không chia được cho 0.....

Còn nếu $b = 0$ ta có vô số x vì mọi số nhân với 0 đều bằng 0.....

.....

Figure 5. *The answer of student 19*

b. Stage 2 - Group work on content 1

In stages 2 and 3, the teacher divided the 42 students into 10 groups (8 groups of 4 and 2 groups of 5). Students had 3 days to organize group work in stage 2 through Google Meet and Google Classroom (the teacher created 10 classrooms for the 10 groups).

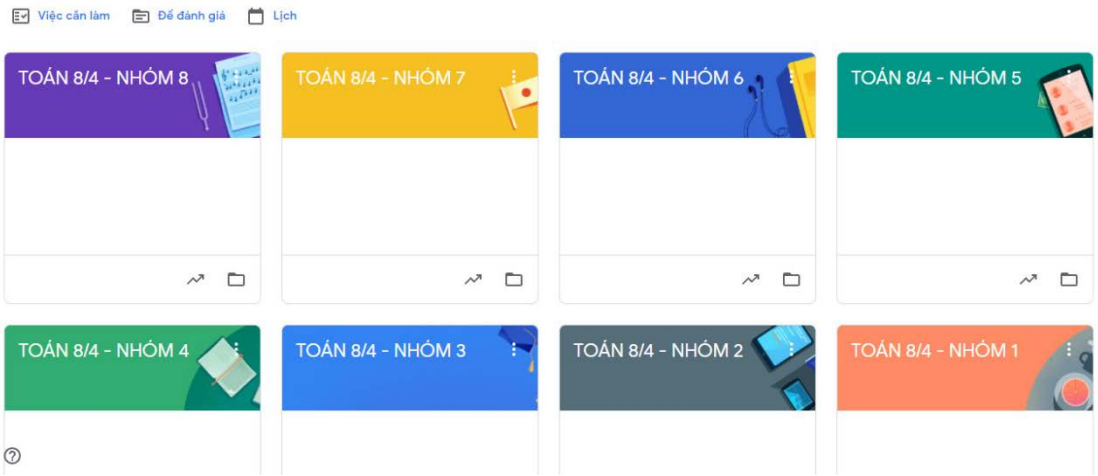


Figure 6. *Classrooms for the groups*

The results indicate that 8 out of 10 groups provided accurate answers for question a (recognizing equations that can be reduced to linear equations). For question b (summarizing definitions of concepts related to linear equations), 6 out of 10 groups answered accurately, and 4 out of 10 groups answered partially accurately.

c. Stage 3 - Group work on content 2

After a week, all groups provided accurate answers to problems 1 and 2 by formulating equations and solving them independently or using MMS.

Bài toán 1. Gọi x (đơn vị: tuổi) là số tuổi của bạn Phương năm nay (điều kiện $x > 0$).

Theo đề bài, ta có: Số tuổi của mẹ năm nay là $x.3 = 3x$ (tuổi)

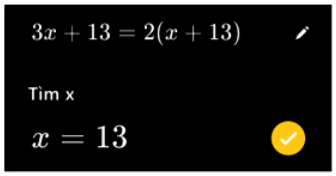
Số tuổi của Phương 13 năm nữa là $x + 13$ (tuổi)

Số tuổi của mẹ 13 năm nữa là $3x + 13$ (tuổi)

Vì 13 năm nữa thì tuổi của mẹ gấp hai lần tuổi Phương nên ta có phương trình:

$$3x + 13 = 2.(x + 13)$$

Giải phương trình bằng ứng dụng trên ĐTDĐ, ta có $x = 13$.



Kết luận: Năm nay, bạn Phương 13 tuổi.

Figure 7. *The answer of Group 5*

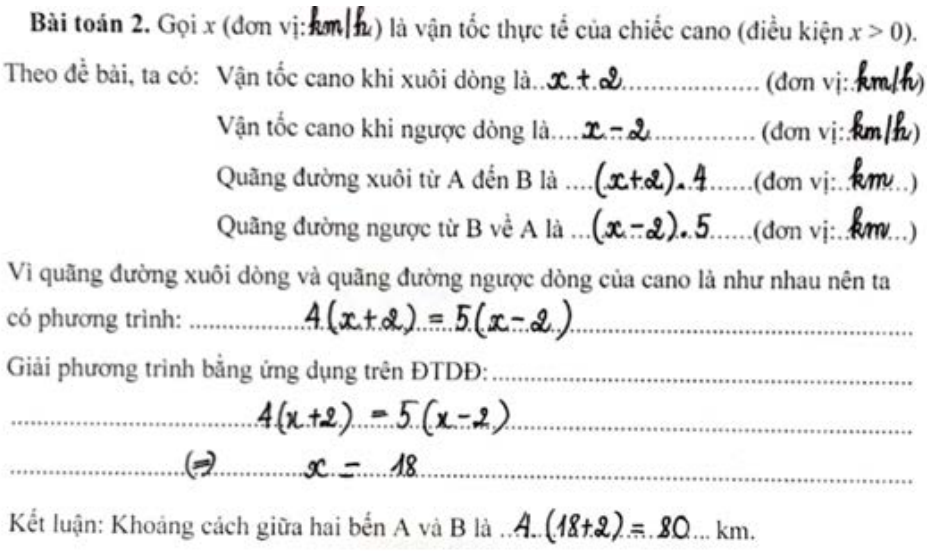


Figure 8. *The answer of Group 6*

All groups presented a general solution method for the real-world problem (question *b*).

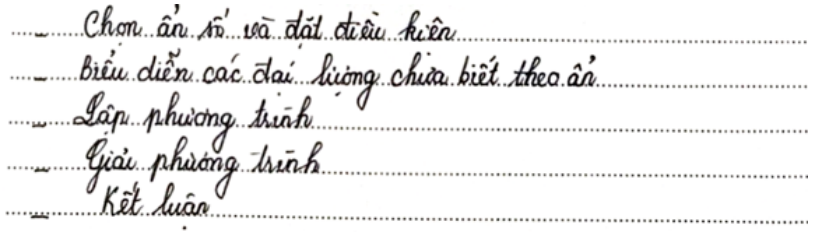


Figure 9. *The answer of Group 4*

All groups completed question *c* with a variety of real-world problems. As mentioned in section 1.3, besides carrying out detailed steps for solving a mathematical equation, MMS also suggests learning websites on this topic such as the Google search engine. This feature helps students to independently explore real-world problems and detailed solutions on these websites. Therefore, the process of independently finding similar problems with the help of AI and solving them assists students in reinforcing the theory learned before. This facilitates teachers in summarizing the overall knowledge in step 3 of the mobile learning process.

3. Conclusions and Recommendations

Mobile learning offers numerous advantages in leveraging learning resources, particularly with AI applications. Our research provides evidence that this form of learning effectively enhances students' self-study competency. The learning outcomes are based on the 2018 Mathematics requirements, focusing on teaching linear equations. The results show that students perform better when self-studying through mobile learning compared to traditional methods. Experimental group students were able to self-study the content of this topic through Mobile learning with the support of the MMS application. In today's context, fundamental math knowledge can be addressed and learned through AI applications. This study aligns with the findings of Duong et al. (2022), indicating that students and teachers

benefited from a blended approach of online and face-to-face teaching during the COVID-19 lockdown. Our recommendation is that teachers should be trained to guide students in self-study using these applications through mobile learning anytime and anywhere. Utilizing students' self-learned knowledge, teachers can organize and structure them during in-person classes: students can present their findings in groups, allowing teachers to adjust (if necessary) and solidify the collective knowledge. Based on this research, we suggest the need for instructional materials to guide teachers in the appropriate use of software and AI applications.

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TỔ CHỨC CHO HỌC SINH TỰ HỌC PHƯƠNG TRÌNH BẬC NHẤT MỘT ẨN BẰNG HÌNH THỨC HỌC TẬP DI ĐỘNG VỚI ỨNG DỤNG MICROSOFT MATH SOLVER TRÊN ĐIỆN THOẠI THÔNG MINH

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TÓM TẮT

Học tập di động (mobile learning) đề cập quá trình học tập thông qua thiết bị di động như điện thoại thông minh, máy tính bảng nhằm cung cấp nội dung giáo dục, tài liệu học tập và trải nghiệm học tập cho người dùng bất kì lúc nào và ở bất kì đâu nhờ vào kết nối internet. Ngày nay, điện thoại thông minh đã trở thành công cụ văn hóa toàn cầu và rất phù hợp để thực hiện học tập di động. Học tập di động là phương tiện phù hợp để thực hiện mục tiêu phát triển năng lực tự chủ và tự học, một trong ba năng lực chung trong chương trình Giáo dục phổ phông 2018. Chúng tôi đã xây dựng các hoạt động tự học cho học sinh bằng cách khai thác ứng dụng Microsoft Math Solver, một ứng dụng AI ra đời trước các AI Chatbox, trong học tập phương trình bậc nhất một ẩn ở lớp 8. Kết quả phân tích định tính và định lượng xác nhận hiệu quả của việc tự học trong hình thức học tập di động thông qua ứng dụng đã chọn. Học sinh có thể tự học ở nhà theo các yêu cầu cần đạt của chương trình Giáo dục phổ thông môn Toán 2018. Giáo viên dựa vào kết quả tự học để tổng kết kiến thức trên lớp.

Từ khoá: phương trình bậc nhất một ẩn; điện thoại thông minh; Microsoft Math Solver; học tập di động; tự học