

## A CASE STUDY BY USING KHAN ACADEMY, AN OPEN-SOURCE ENVIRONMENT

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### ABSTRACT

The purpose of this study was to analyze the effects of the flipped-classroom approach in teaching mathematics using Khan Academy, an open-source learning platform, and to examine students' views about their experiences. The experiment was evaluated in both qualitative and quantitative ways. After introducing Khan Academy environment to a group of students at a private school in Hanoi, we organized several high school mathematics teaching units. The students were then observed as they learned the material in the flipped-classroom format. The different types of assessment such as formative and summative assessment designed and integrated within the environment were analyzed in light of competency-based assessment approach. The research found that the flipped-classroom approach using Khan Academy boosted student achievement in mathematics while the diverse tests such as QCM, open-end question on the platform played a vital role in the learning process. We also found that teachers need to design additional teaching resources to better integrate Khan Academy environment into the Vietnamese classroom.

## 1. INTRODUCTION

Information, communication, and working styles have changed in the 21<sup>st</sup> century. Consequently, computer and electronic technologies are essential in every field, including education. Educators, particularly those who are responsible for challenging mathematics courses, have enabled students to better understand the concepts involved using technologies (Hoyles, 1998). The technologies also provide opportunities for students to work on real-life problems and to apply the concepts in a variety of contexts. The use of information communications technology (ICT) in mathematics courses is beneficial to students (Laborde, 1993). Teachers use their knowledge about teaching and learning as well as technology to promote students' learning experiences and creativity in computer-mediated environments (Niess, 2005). Moreover, teachers are expected to prepare their teaching content by using a variety of types of software and to adapt them to the new learning environment. In addition to teachers' efforts in using these education technologies, it is important to consider how and with which approaches these technologies could be used in the classroom learning environment. The flipped classroom, a widely used blended-learning model (Sahin, 2015) can enable teachers and students to re-design the learning environment.

Basically, in a flipped (or inverted) classroom, material that is traditionally covered in class is learned at home, and exercises that are traditionally assigned as homework are completed in class (Bergmann 2012). The traditional model of instruction is teacher-centred; the teacher gives lectures during the lesson and assigns students homework to do at home. The flipped classroom reverses traditional education: the teacher prepares and delivers the content outside the classroom, and devotes class time to student collaboration and discussion. This arrangement offers students more opportunities to engage more deeply with the material and to learn from both the teacher and classmates. The flipped classroom calls on the teacher to plan activities, videos, presentations, or study notes to deliver content outside of the classroom. It calls on students to review these materials before they attend the class.

Therefore, research on the use of a technological platform in flipped classroom model has scientific and practical significance. This is especially important in the context of the Covid-19 pandemic in Vietnam, when more teaching is taking place online instead of face-to face mode. Below, we present preliminary research results on using Khan Academy's platform in teaching the mathematical concept of functions to high school 10th-graders following the flipped- classroom model. The purpose of the research is to assess the effectiveness of the flipped classroom teaching methodology using The Khan Academy and Desmos software.

## 2. LITERATURE REVIEW

Bergmann (2012) stressed that training and support for teachers is critical to overcoming potential barriers in adopting a flipped classroom. While some critics fear that Khan Academy's importance can result in standardization and deprofessionalization (Sahin & Bergmann, 2012) thank to the new way of teaching, others pointed out that educational videos are important teaching tools. Khan Academy platform provides numerous activities, instructional videos, and a personalized learning dashboard that enable students to study at their own pace in and outside of the classroom. Khan Academy materials can be used to guide students at both beginning (preschool) and advanced levels because they use adaptive technologies. The teacher's dashboard offers a summary of class performance, allowing instructors to monitor the progress of all students. Khan Academy, founded by Salman Khan, has grown into an 80-person organization that aims at providing a free world-class education for anyone, anywhere. Khan Academy's lessons are available in many different languages and presented in an entertaining environment that takes into consideration students' knowledge gaps (Khan, 2016). Videos on Khan Academy usually last between seven and 14 minutes, and provide opportunities for students to identify, explain, and practice different mathematics concepts using relevant software (Zengin, 2017).

In the flipped-classroom model, students first study the rich content of Khan Academy at home before the actual class session. Their time in class, under the guidance of the teacher, is equally important; if the preparation done by students on their own in advance is not complemented with planned activities during the shared class period the positive effects of the flipped model may not emerge as desired. Thus, even if students understand the general framework of the concepts when they come to class session, teachers must prepare class-time lessons that allow students to deepen their understanding of the concept. In some cases, content covered by the Khan Academy can be enriched with supplementary software. Thus, students must be offered contents with relevant software. They must also have opportunities to practice using the software under the guidance of the teacher in the classroom. Numerous open-source software programs promote the design of such learning environments in mathematics teaching. Maxima, GeoGebra, Desmos are examples of such systems. Open-source programs offer alternative content to students and teachers in designing the learning environment. For this study, we chose Desmos because it is available in a variety of languages and is easily used and set up in classroom session. Desmos was used during the in-class portion of the flipped classroom.

The flipped classroom can provide greater explorative opportunities for students if their classroom activities are well-planned and guided by the teacher. Moreover, using mathematics software with in-class activities can promote the efficiency of the flipped-classroom strategy. Few studies with the flipped classroom approach in mathematics education have been carried out, and they provide limited explanations on how in-class and out-of-class activities of the flipped-classroom approach were designed.

In this research, we, together with the 10th graders of O. schools, used Khan Academy's free learning platform to study the topic of functions.

Our research questions were:

- *How does the flipped classroom methodology using Khan Academy's free learning resources and mathematics software support students?*

- *What are the students' opinions of using Khan Academy's learning resources and mathematics software with a flipped-classroom approach in studying the topic of functions?*

## 3. RESEARCH METHODS AND RESULTS

### 3.1. Population and method process

In this research, 20 students in grade 10 at a private O. Schools, Hanoi, Vietnam comprised the study group. The students consisted of 12 males and 8 females.

The research study lasted 4 weeks.

*Week One:*

The students learnt how to use Desmos, which is a graphic calculator program implemented as a browser application and Khan Academy – a free basic learning site.

*Week Two:*

The student learnt supplementary and important knowledge corresponding to the content of Mathematics program of grade 10 in Vietnam:

- Functions: calculate the value of a function following the formula or graph, domains and range of a function, maximum and minimum of a function on closed interval and halfopen interval, slope of a linear function, function and linear equation.

- Absolute value and piecewise functions;

- Quadratic functions and equations: graph quadratic functions given vertex form, graph transformation, quadratic equations.

b) Types of exercise in Khan Academy. Khan Academy assigned two main types of tasks: watch video lectures and complete practice exercises. Both could be assigned to students depending on different learning goals. For instance, to prepare for the lesson about the definition of a function, the students were asked to watch the video “What is a function?” and calculate the value of a function before class. They also were encouraged to watch the video “Worked example: Evaluating functions from equation” before completing the exercise. Figure 1 shows what students see on a learner’s dashboard.

c) How to teach grade 10 students functions using Khan Academy?

At-home learning tasks were assigned

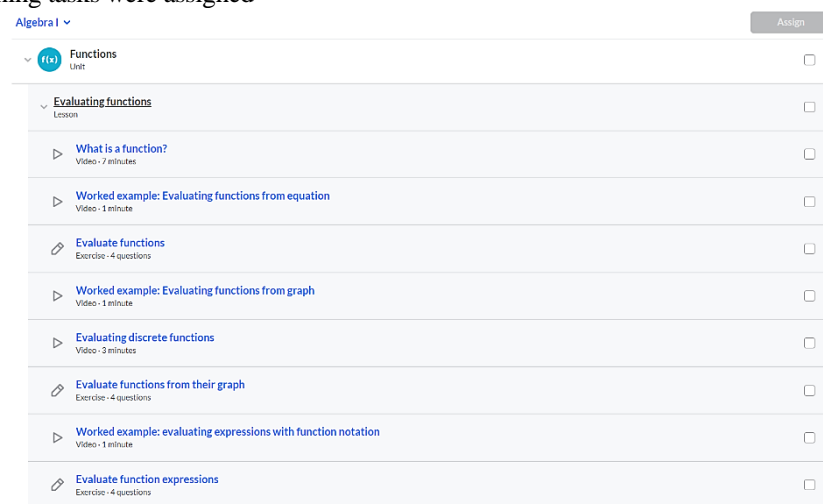


Figure 1. Learning material for topic “Function”

In this stage, their main learning tasks included video lectures and practice exercises. In the video “What is a function?”, Khan Academy offered a different approach to defining a function from that in the Algebra 10 text book. In the second video, “Worked example: Evaluating functions from equations”, students were given detailed instructions on how to calculate the value of a function given a formula. They could self-study before coming to class by completing exercises provided in the section “Evaluate functions”.

All the provided tasks were offered as multiple-choice questions or fill-in-the-gap exercises, enabling students to easily respond on their computers or mobile phones. Once the students filled in their answer, they could check by pressing “Check”. If their answer was incorrect, they could use a hint in the menu “Use a hint”.

The diverse questions was divided into different levels so that students could acquire a suitable amount of knowledge. After answering the questions, the students got their score. If they made a mistake, they were able to redo it and this mistake would be included in their learning report.

*Week Three:*

The students had already watched videos about functions and completed their learning tasks provided by Khan Academy before coming to class.

- Students’ self-assessment: Students can log into their own account and follow their academic assignments and completion status. This can help students pinpoint their strengths and weaknesses and develop skills and techniques to overcome mistakes and shortcomings. Students who are able to assess their progress are better equipped to ask for help or suggest methods to manage and promote their own learning.

- Teachers assess students’ learning: Using the teacher’s dashboard, teacher can access and monitor the progress of each student, enabling them to reward and motivate positive behaviors and check in with students who are struggling or inactive. The features of the Teacher Dashboard include:

- Activity overview: to view student activities, including working time student spends on both assigned assignments and any other assignments that the student studies on Khan Academy. Figure 2 shows the activity overview of a student named Harry Nguyen.

| DUE DATE & TIME    | ASSIGNMENT                    | STATUS        | ATTEMPTS | BEST SCORE |
|--------------------|-------------------------------|---------------|----------|------------|
| Feb 27th, 11:59 PM | Intro to dimensional analysis | Not completed | -        | -          |
| Feb 27th, 11:59 PM | * Rate conversion             | Not completed | 0        | -          |
| Sep 22nd, 10:00 PM | ▶ Translating points          | Completed     | -        | -          |
| Sep 22nd, 10:00 PM | * Translate points            | Completed     | 2        | 100        |
| Sep 22nd, 10:00 PM | ▶ Determining translations    | Completed     | -        | -          |
| Sep 22nd, 10:00 PM | ▣ Determining translations    | Completed     | -        | -          |
| Sep 22nd, 10:00 PM | * Determine translations      | Completed     | 1        | 100        |
| Sep 22nd, 10:00 PM | ▶ Translating shapes          | Completed     | -        | -          |
| Sep 22nd, 10:00 PM | ▣ Translating shapes          | Completed     | -        | -          |

Figure 2. Teacher dashboard related to students for a class in Khan Academy

- Course Mastery: the entire working process and mastery of the student's course. Teachers can assign multiple objectives or change student objectives.

- Assignments: when the teacher assigns a task, the task will appear on the student's page. Teachers can keep track of scores for each assignment, receive detailed reports (number of trials on assignments, scores for each assignment, etc.). Teachers can change the student's assignments appearing on the report.

#### Week Four:

Students completed worksheets using their computer in the class.

After checking their completion of learning tasks assigned at home, the teacher asked questions about the content students were required to study. The teacher corrected all the inaccuracies and provided more information so that students could better understand the concept. Classroom hours were spent on checking exercises, applying learnt theories to solve new problems, and discussion. The teacher was a facilitator and supporter rather than an instructor only.

Khan Academy allowed the teacher to keep track of time spent on watching videos, completing exercises and the total amount of time of self-study for each student. From this, teacher was able to adapt his/ her teaching plan to better meet the needs of all students.

In the lesson of functions using the flipped-classroom approach, group learning activities were conducted using the mathematics software. Students were grouped by the teacher based on their skill level, and students were encouraged to discuss and share their knowledge with each other. At several points, the teacher asked students questions such as, "What do the concepts mean and why so?" Students were asked to come up with their own answer before pairing with a partner to work out possible solutions. At the end of the lesson, students were asked to share their ideas with the whole class.

### 3.2. Research results

Our survey asked students and teachers about their experiences in a flipped classroom. The results are presented in Table 1.

Table 1. Qualitative data sheet (results are taken from survey on Google form)

| Category   | Code                    | Frequency | %  |
|------------|-------------------------|-----------|----|
| Advantages | Enhancing understanding | 18        | 90 |
|            | Visualization           | 12        | 60 |
|            | Promoting retention     | 12        | 60 |

|                       |  |    |    |
|-----------------------|--|----|----|
|                       | Making understanding much easier                     | 9  | 45 |
|                       | Coming to the class prepared                         | 7  | 35 |
|                       | Concretization                                       | 7  | 35 |
|                       | Making difficult concepts easy                       | 6  | 30 |
|                       | Like the topic                                       | 6  | 30 |
|                       | Moving away from memorization                        | 5  | 25 |
|                       | Understanding faster                                 | 5  | 25 |
|                       | Promoting productive learning                        | 4  | 20 |
|                       | Increasing motivation                                | 4  | 20 |
| Students' suggestions | Using Khan Academy and mathematics software together | 18 | 90 |
|                       | Must be implemented in all subjects                  | 5  | 25 |
| Disadvantages         | The inadequacy of using computers                    | 4  | 20 |
|                       | Difficulties in using mathematics software           | 2  | 10 |

The flipped-classroom model designed using the Khan Academy materials and Desmos mathematical software enabled students to understand the concepts in more depth. Many students said they could retain the knowledge better; and most said that the flipped approach helped them to learn concepts more easily.

For example, students said:

+ *Regarding the preparedness level, we come to the class in a much better way, and we watch the subjects which we are going to study via computer through videos and then we study them in the class. This has a positive effect on my learning. I noticed that I comprehended much better.*

+ *Using the Khan Academy materials and mathematics software provides more visuals in mathematics courses and students are better prepared before coming to the class.*

+ *When subjects are supported with visuals, they became more understandable. I could construct the examples much more easily with my logic.*

+ *I believe that this model has been very helpful for us to come to the lessons prepared. Because it enhances the level of our prior knowledge, it enables us to learn more clearly and permanently.*

A total of 60% of the students stated that the approach promoted visualization and retention of knowledge. The following views of two students can be given as examples.

+ *Khan Academy should be widely deployed as it is supported with images, easy to remember and it keeps us away from memorization.*

+ *When we see pictures, they are easily remembered, and I don't forget what I saw. It allows me to remember easily. I understand the function very well and I will never forget it.*

Also nearly 30% of the students say they understand concepts much easier with this method. For example:

+ *I couldn't solve function exercises before, and I was afraid of learning it but now I can understand and solve them confidently.*

+ *Thanks to this model, we understand that difficult subjects will be started more easily.*

One student shared the following ideas:

+ *I think that it has benefits for concretizing abstract concepts.*

+ *Coming to the class prepared helps me to eliminate the prejudices against the course. Thus, I liked flipped classroom.*

+ *We have to come to the lesson prepared with this model. This enables us to understand much more easily and quickly.*

Only 30% of the students stated that it was possible to learn difficult mathematics concepts simply with the flipped approach designed using Khan Academy materials and mathematics software. 25% of the students stated that the approach moved them away from rote memorization. One student said: *I learned the functions rationally because of the flipped-mathematics classroom.*

Most of the students stated that in the flipped-classroom approach, Khan Academy materials and mathematics software should be used together. Moreover, five students (25%) stated that they wanted this approach to be used in all subjects. One student said:

+ *Khan Academy teaches learning because it teaches the complex subjects in a simple way... The model and Khan Academy are ideal to teach difficult subjects easily. As I said, complexity is reduced to simplicity. There is only one*

thing missing here. The lack of visuals (graphs, diagram, etc.) in some videos are completed by GeoGebra and Maxima. All three (GeoGebra, Maxima and Khan Academy) could go well together. It is a very good model. In my opinion, it must be used with all subjects.

However, 20% of the students stated that they had difficulty due to lack of information about how to use a computer while 10% of the students stated that they had difficulty with using mathematics software. Two students' views can be given as examples of this category: *I had difficulty because of lack of information about how to use a computer; I had difficulty with generating graphics with software.*

### 3.3. Limitations

The research has two fundamental limitations. One is related to the quantitative side of the research. The quantitative part of the study was designed with a single group, which limits the ability to make comparisons. Another limitation is that the students mostly focused on positive effects of the approach. As a result, the disadvantages or negative effects remain largely unexplored.

## 4. DISCUSSION AND CONCLUSION

Within the context of this study, students successfully used Khan Academy materials outside the classroom, and especially in advance of classroom activity. Quantitative data demonstrated that most students believed they understood the concepts much better as a result of using the flipped-classroom approach that combined the Khan Academy materials and mathematics software. Furthermore, the combined use of Khan Academy materials and mathematics software appeared to make lessons more visual and concrete for students. Our findings suggest that students were better prepared to discuss concepts during classroom sessions and were able to reinforce their classroom learning. The visuals promoted retention of knowledge, suggesting that a more visual teaching environment might move students away from memorizing toward a more conceptual understanding of the material. Qualitative data revealed that the flipped-classroom model using Khan Academy materials and mathematics software promoted student achievement. Our results correspond to other studies on the flipped-classroom approach in mathematics teaching (Sahin, 2015). Although this approach had a positive effect on most students, some students had difficulties due to their unfamiliarity with the computer and software. Therefore, this approach becomes a disadvantage for students who do not know how to use a computer. With adequate Internet connection, the flipped-classroom model supported by Khan Academy materials outside of the classroom and with free open-source software can be an effective model for not only students at The O. Schools but also other educational institutions in both Vietnam and abroad.

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