# Sifte-Math, A Sifteo based Mathematics Assessment Serious Game for Deaf Children

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***Abstract*—The limitations of deaf children in language lead to the delay progress in teaching and learning process of deaf children compared to normal children, especially in mathematics. This also made teacher hard to understand to what extent the deaf students understand the lesson taught by teacher. Using the advantage of serious game which can help motivate students, this research used Sifte-math, a Sifteo based serious game to test the ability of deaf students in basic mathematics lesson for elementary school, hoping that the game can be an alternative tool for assessment. Sifte-Math was tested on seven students in a school for disabled children in Surabaya, Indonesia. Six from seven students who tested the game responded with enjoy playing the game. Four of them said they prefer to use Sifte-Math as their assessment tools instead of paper and pen, while one student prefers the basic paper and pen, and the other two students prefer both.**

***Keywords— deaf students, mathematics, serious game, Sifteo***

## I. INTRODUCTION

The fast development of game industry made the purpose of the game has developed not only as a pure entertainment tool, but also as an alternative tool for learning, known as serious game. Serious game is a game which entertainment is not its main purpose. Some of serious games that have been developed are used for different learning topics. Tanah, a game developed by Opendream, a game developer who collaborated with UNESCO Bangkok and Red Cross / Red Crescent Global Disaster Preparedness Center (GDPC) is a game that teach its players how to survive from earthquakes and tsunamis, following the success of Sai Fah, a game developed by the same game developer to give players basic knowledge about flood and how to be save from it [1]. In other topic, there is Pulse!!, an Emergency Room simulation for medics [2]. Regardless of the purpose about what the serious game is made for, researches show that serious games effectively motivate its players to learn [3] [4].

Education is needed for all people, deaf children included. Researches show that deaf learners indicate delay progress especially in mathematics compared to normal students [5] [6]. The degree of deafness (mild, cannot hear sound quieter than 25-45 dB; moderate, cannot hear sound below 40-75 dB; severe, cannot hear sound below 75-90 dB; and profound, cannot hear sound below 90 dB) is not the reason of this delay [7], rather, it is more because of deaf learners' limited understanding of language and vocabulary [6] [7].

For teaching and learning activities, communication is important between teacher and student to know to what extent the students understand the lessons that have been taught. However, the limited ability of deaf students to communicate makes it difficult for teachers to know whether the student has understood the lesson being taught or not. This makes teaching and learning activities for deaf children even more difficult, so teacher has to find a way to ease this process.

This research is using Sifte-math, a Sifteo based serious game to test the deaf learner's ability of basic mathematics lesson. Sifte-math is developed in hope to be an alternative assessment tool in teaching and learning environment especially for deaf students to test the basic mathematics ability of deaf learners, to help teachers understand the ability of their students as well as to what extent the deaf learners understand the lesson that have been taught.

The reason Sifteo device is used for this research is because of its interaction that can attract the attention of students. Because Sifteo is like a new "toys" for them, students may think that the device is interesting and wants to try the game. Using Sifteo device can eliminate the chance of students losing their focus and straying to other applications during the assessment while playing the game in other devices like tablet or laptop, especially for intellectually disabled students who tends to easily gets bored.

## II. THE GAME

### A. Sifteo

Sifteo is a digital cube shaped game made by Jeevan Kalanithi and David Merrill [8]. The standard package has one server block, one USB cable, and three battery-powered play cubes each sized 1.5 inches width which can connect to each other. The specification of Sifteo cubes is as follows: 32-bit ARM CPU, 128 x 128 color TFT LCD, 3-axis accelerometer, 8MB Flash, 2.4 GHz wireless radio, proprietary near-field object sensing technology.

Combining digital game as well as board game, it has full color LCD touch screen and sensors on each side of the cubes. Each cube can be tilted, pressed, shaken, and be adjacent to each other to play the games. The server block is used to stop the game, back to main menu, and turning the Sifteo cubes on and off. This server block also has an USB port to connect Sifteo cubes to PC in order to input or delete the game from the device. If a command from Sifteo SDK's command prompt window is called while the server block is connected, the game log can be shown. Fig. 1 shows how Sifteo cubes looks like.

Although Sifteo is discontinued in 2014 [9], it garnered many interest from many people and eventually lead to the start of Joyscube, a gaming device which has similar design with Sifteo but improved some of its features, such as better quality of LCD screens and speaker, bluetooth connectivity, and power-saving operation mode so the device can works longer than the original Sifteo [10]. Joyscube is still in pre-order session at the time this research is written.

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Fig. 1. Sifteo cubes [8]

### B. *Competence Used*

Sifte-Math uses mathematics competency for first grade elementary school in Indonesia as assessment material. Citing the problem discussed by Risdianti in her journal [11], deaf students have problems in solving addition and subtraction problems, so this research is using competence points that are limited to addition and subtraction.

There are four competence points used in the Sifte-Math. The first competence point used is "introduction of numbers" (CP1). The second competence point is "sequence of numbers" (CP2). The third is "addition of one-digit numbers" (CP3), and "subtraction of one-digit numbers" (CP4) is the last competence point. Each competence point has different number of questions. The number of question in each competence point is determined based on the difficulty level of each competence point. The details of competence used and the number of question of each competence point can be seen on Table 1. The question designed with two designs, picture design and number design. In picture design, player will need to count the total picture before solving the question.

## III. GAME DESIGN

### A. *Interface*

The questions and multiple answer choices in Sifte-Math is designed as .png file sized 128 x 128 pixel so that it can fits with Sifteo screen. The question is designed with simple yet colorful pictures so that the question can be seen clearly in Sifteo cubes and so players will not be bored while doing the assessment. After player choose an answer, a screen transition will appear to let the player know whether the answer is correct or incorrect before continuing to the next question. Asset initialization is separated from the game's main code so the question and multiple answer choices can be easily changed according to the needs.

TABLE 1. COMPETENCE POINTS AND NUMBER OF QUESTIONS

| CP | Competence Point | Number of Question(s) |
|---|---|---|
| 1 | Introduction of numbers | 1 |
| 2 | Sequence of numbers | 2 |
| 3 | Addition of 1 digit numbers | 3 |
| 4 | Subtraction of 1 digit numbers | 4 |


Fig. 2. The transition screen if the answer is correct


Fig. 3. The transition screen if the answer is incorrect

### B. *Rules*

There are ten multiple choices in Sifte-Math that need to be solved by players. Sifte-Math is run through Sifteo cubes which the server block is first connected to PC or laptop to access Sifteo SDK's command prompt windows to see the game log. If the answer is right, player will get a score, but if the answer is incorrect, no score will be added in total score. The player can see whether the answer chosen is correct or incorrect through the transition screen. Fig.2 shows how the transition screen looks like when the answer is correct and Fig.3 shows how the transition screen looks like when the incorrect.

Game log shows what test number the player is currently working on, the answer status, what answer choice the player chooses, and player's current score. Answer status shows whether the answer chosen is the correct answer or incorrect answer. Fig.4 shows how Sifte-Math log looks like, and Fig.5 shows the game flowchart.

### C. *How To Play*

Sifte-Math started by the display of question on Sifteo cube 1, and answer choice on Sifteo cube 2. The initial game screen can be seen on Fig. 6. There are three (3) answer choices that can be chosen simply by pressing Sifteo cube 2's screen until player get the desirable answer. After picking the answer, player needs to adjoin the right side of Sifteo cube 2 with the left side of Sifteo cube 3 to lock the answer. After locking the answer, the answer status that has been chosen will show in all Sifteo cubes. To proceed to the next question, press the Sifteo cube 1's screen.

After all ten questions are answered, the display will show the total score the player got from the assessment, and the total time used by player to do the assessment. Fig. 7 shows how the Sifte-Math screen looks like when displaying the total score.

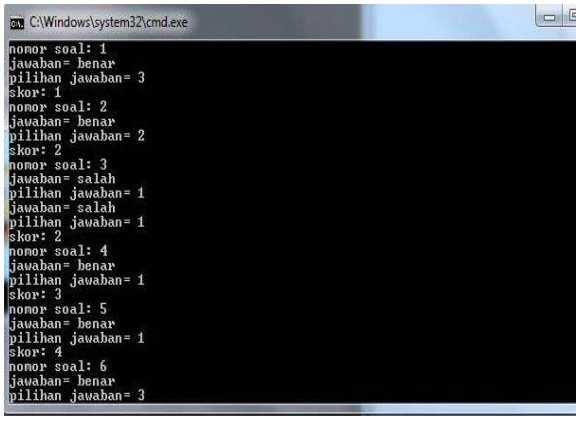


Fig. 4. Sifte-Math's game log

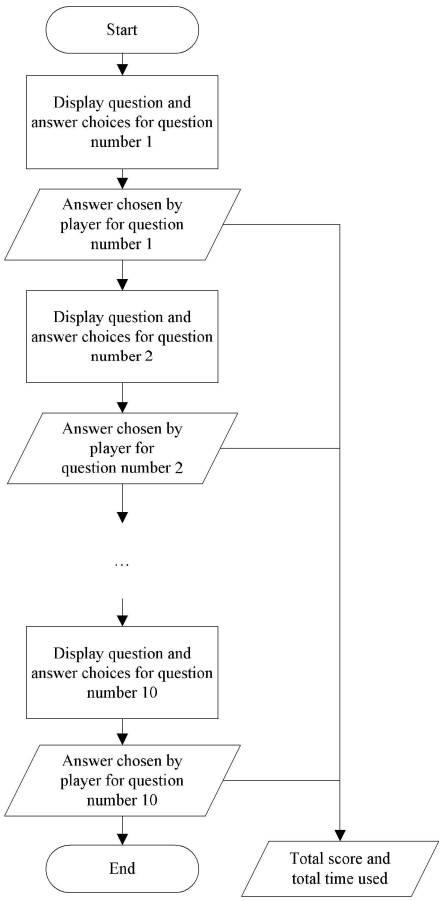


Fig. 5. Game flowchart


Fig. 6. Game screen


Fig. 7. Total score screen

## IV. TESTING

Sifte-Math prototype was tested at a school for disabled children in Surabaya, Indonesia. Seven deaf students, three of them are also intellectually disabled were the tester of this game. The number of student tested is very few because many schools are closed during CoVID19 pandemic, so the tested students are only those who tested before the pandemic spread. In addition, the school is a school that many disabled students other than deaf students attend, so only seven deaf students can be tested. The result of the test can be seen in Table 2.

There are ten questions total with four different competence points. The distribution of question is as follows: one "introduction of numbers" question (CP1), two "sequence of numbers" questions (CP2), three "addition of one-digit numbers" questions (CP3) and four "subtraction of one-digit numbers" questions (CP4).

The assessment result shows that the problem most students gave incorrect answers is question number 3 with five students wrong. Then question number 7 with three students wrong. Both questions are using "sequence of numbers" competence point (CP2).

Questions using "subtraction of one-digit numbers" competence point (CP4) are question number 2, question number 5, question number 8 and question number 10. For question number 2, number 5 and number 8, two players choose incorrect answer for each question, and for number 10 three students choose incorrect answers.

All problems with "addition of one-digit numbers" competence point (CP3) have one student choose incorrect answer on each question (question number 4, question number 6 and question number 9). Question number one which is "introduction of numbers" competence point (CP1) has all students choose the correct answer. The total score and total time used by students tested can be seen on Table 3.

After the students finished playing Sifte-Math, the questionnaire survey form was given for each student to fill. The first question is whether the student likes playing Sifte-Math. Fig.8 and Fig.9 shows the result of the survey. Six students choose yes while one student choose no.

The second question is which assessment tool the students prefer. Four students prefer using Sifte-Math than the basic paper assessment, while one student prefers paper assessment. The other two students enjoy using both as assessment tools.

TABLE 2. ASSESSMENT RESULTS

| Student's ID | Question Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* |
| I | correct | correct | incorrect | incorrect | incorrect | incorrect | incorrect | correct | incorrect | incorrect |
| II | correct | correct | correct | correct | correct | correct | correct | correct | correct | incorrect |
| III | correct | incorrect | incorrect | correct | incorrect | correct | incorrect | incorrect | correct | incorrect |
| IV | correct | correct | incorrect | correct | correct | correct | incorrect | incorrect | correct | correct |
| V | correct | correct | incorrect | correct | correct | correct | correct | correct | correct | correct |
| VI | correct | incorrect | incorrect | correct | correct | correct | correct | correct | correct | correct |
| VII | correct | correct | correct | correct | correct | correct | correct | correct | correct | correct |

TABLE 3. TOTAL SCORE AND TOTAL TIME USED

| Student's ID | Total Score | Total Time Used (in seconds) |
|---|---|---|
| I | 3 | 327,657 |
| II | 9 | 214,818 |
| III | 4 | 310,345 |
| IV | 7 | 286,263 |
| V | 9 | 203,512 |
| VI | 8 | 265,801 |
| VII | 10 | 154,851 |
| Max | 10 | 327.657 |
| Min | 3 | 154.851 |
| Average | 7.142857143 | 251.8924286 |

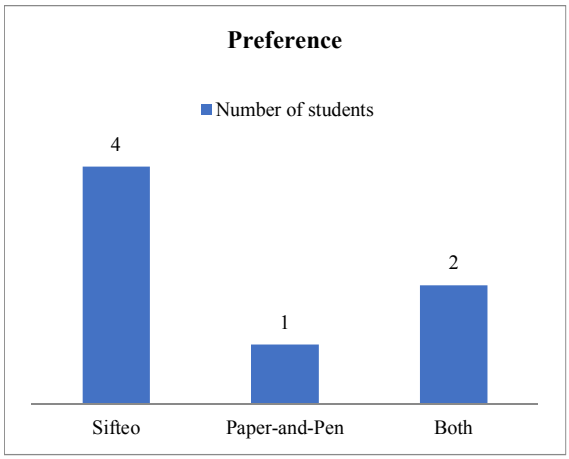


Fig. 8. Preference of assessment tool

## V. TESTING EVALUATION

As seen in Table 3, the highest score student who tested Sifte-Math achieved is 10 out of 10 by student VII. The lowest score is from student I with 3 out of 10. The average score of students who tested Sifte-Math is 7,14. Meanwhile, the longest time used by students who tested Sifte-Math is 327,657 by student I, while the shortest time used is achieved by student VII with 154,851 seconds. The average time used by students while doing the assessment is 251,892 seconds.

The testing result shows students who took longer time to do the assessment get lower score than those who used shorter time to do the assessment. This is because those students took longer time to count. There is 172,876 seconds difference of the longest time used and the shortest time used to do the assessment.

Table 4 shows the detail of testing result in order of competence points. The highest score in all competence points is 10 out of 10. Except competence point (CP) 1, the lowest score in all competence points is 0, and because all students answered correctly in CP 1 questions so the minimum score is 10. The average score for CP 1 is 10, while the average score for CP 2 is 4,286. This means students who tested Sifte-Math finds CP 2 questions are more difficult than other CPs. Average score for CP 3 is 8,571 and for CP 4 the average score is 6,786. This means CP 4 is the second most difficult CP for all students who tested Sifte-Math. Score of students for each CP can be seen in Fig. 10.

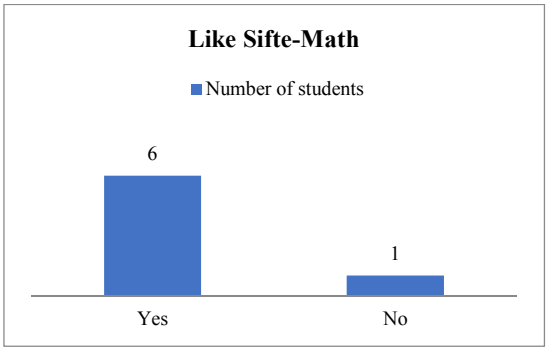


Fig. 9. Survey result of whether students like Sifte-Math or not

TABLE 4. STUDENT'S SCORE BASED ON CP

| Student's ID | Score Based on Competence Point | | | |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |
| I | 10 | 0 | 0 | 5 |
| II | 10 | 10 | 10 | 7.5 |
| III | 10 | 0 | 10 | 0 |
| IV | 10 | 0 | 10 | 7.5 |
| V | 10 | 5 | 10 | 10 |
| VI | 10 | 5 | 10 | 7.5 |
| VII | 10 | 10 | 10 | 10 |
| Max | 10 | 10 | 10 | 10 |
| Min | 10 | 0 | 0 | 0 |
| Average | 10 | 4,2857143 | 8,5714286 | 6,7857143 |

## VI. COMPARISON WITH OTHER GAMES

A lot of games have been made to help children in learning mathematics and to monitor children's ability in mathematics. Those games are available in website and mobile device. Math Games [12], which is available in Android device is one of it. The game that has more than 10 million downloads in Playstore by the time this paper is written is using basic mathematics for its assessment contents. But the assessment report in this game only shows user' total correct answer(s) and total incorrect answer(s) without knowing what question the user did in assessment and what answer the user choose, so it's hard for teacher to know what difficulties user (in this case student) face while doing this game.

Another game that is available in Android and iOS device is Math Test for Grade 1, 2, 3 [13]. This game used mathematics material for grade 1, 2 and 3 for elementary school. The UI design is simple and it gives answer explanation for every question after user choose an answer. But this game doesn't show the assessment result, so is not suitable for assessment.

The other game that has assessment monitoring content is Splashlearn [14]. Splashlearn is a paid learning program that shows progress, performance, and time the user spent that can be monitored by teacher and parent. Many mathematics competences from kindergarten grade until grade 5 is available to choose, with 25 free practice questions for first free trial. There's reward for user's achievement like coins and stars that can be exchanged with in-game objects. But this game has a lot of questions in one session that is not suitable with deaf children who tends to be easily bored and lose focus.

Sifte-Math shows the user's answer and the status of the answer. There is interaction with user while doing the assessment so the user will not be easily bored and keep focusing on doing the assessment. Assessment material can also be adjusted to the needs of teaching and learning activities so teacher has full control with the assessment. These advantages made Sifte-Math is more suitable for deaf children assessment than other games.

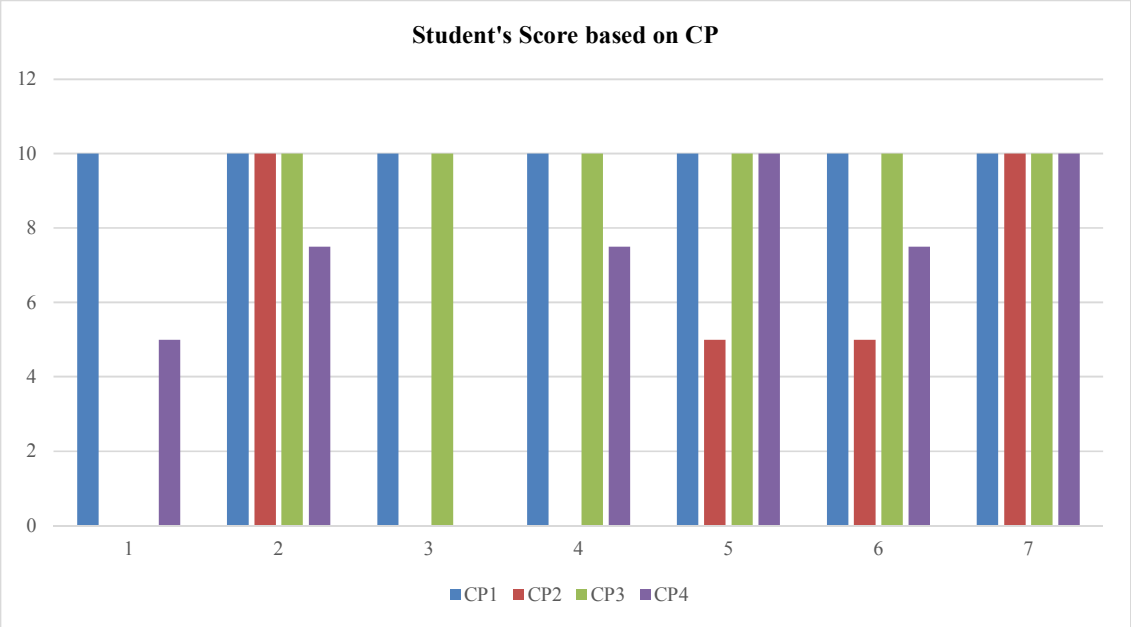


Fig. 10. Chart of student's score based on competence points

## VII. Conclusion and Future Works

Sifte-Math is developed hoping to be an alternative assessment tools for basic mathematics lesson. The design is made as simple as possible so that the players can focus on the assessment, yet colorful so players will not be bored when doing the assessment.

The student seems to find it difficult when it comes to "sequence of numbers" competence point problems (CP2). There are two questions from the "sequence of numbers" competence point in Sifte-Math, which are the question number 3 and number 7. Question number 3 is using four different set of pictures (horse, flower, butterfly, and orange) with different total pictures of each set. The students must count all pictures in each set and then sequence it in the right order. Three students has trouble counting it and end up count incorrectly, while two students has trouble choosing the answer. Question number 7 has three random one-digit numbers where students have to sequence it from the smallest number to the biggest number. All three students who choose the incorrect answer for question number 7 are intellectually disabled. Overall, two from seven students (28,57%) have low ability of the material assessed, two (28,57%) students have average ability, and three students (42,86%) have high ability of material assessed with Sifte-Math. The two students who have low ability are recommended to have material repetitions.

However, problem arises with the use of Sifte-Math. It is because the students and the teachers are not familiar with Sifteo device, so the Sifteo device must first be introduced to the students, and the students must be guided when doing the assessment to avoid any confusion during playing the game that led to choosing the wrong answer. The teachers should also be informed about how to install the Sifteo device on the PC or laptop and how to access the game log.

Regardless of the problem, six from seven (85,72%) students who tested Sifte-Math responded the questionnaire survey by saying that they liked Sifte-Math. When asked about why the students enjoy playing the game, "fun" and "challenging" were the answer. One (14,28%) student who responded the questionnaire survey with "doesn't like Sifte-Math" said that the game is difficult to operate. Four from seven (57,14%) students prefer Sifte-Math for assessment tool rather than basic paper assessment. It's because the game is interesting and fun to play. The teachers were also asked about their opinion with Sifte-Math. They said it's helpful to make the students focus with the assessment, and even having fun doing it.

Since the questions and answer choices database for Sifte-Math are stored in separated asset folder as .png file, the competence points, questions and answer choices can be easily changed to match the needs of other assessments. Moreover with the Sifteo device's design and interaction that can be considered new for students and children, it can attract their attention to do the assessment while thinking it is a fun game. Sifte-Math can also display the total time players used to do the assessment, which is hard to do in paper based assessment, so it can help for classifying or clustering the student's ability based on the total score and total time used.

Sifte-Math can be developed with more features for assessment in the future. An adaptive testing system and level system can be added in Sifte-Math so the assessment for each student can be more accurate.

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