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Interactive Mathematics Lessons by Scratch

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Scratch is a visual programming tools that is widely used in many lessons. While many of the lessons use the coding features of Scratch, teachers may also use the interactive features in their lessons. In a course for in-service primary school teachers, on the use of technology for the school-based learning and teaching, teachers had an experience on how Scratch can be used to facilitate learning. Starting from no programming history, teachers spent 3 hours each on 4 topics including Take-Away Model, The Four Operations, Divisibilities, and Area of Simple Figures, via step-by-step procedures on setting up animations within the theme that would attract students, and with the interaction responses such as text and sound, they successfully handled the use of Scratch and could design and make their lessons perfectly to their students. While teachers suggest learning should be extended to the second and the third classroom, with this easy-to-learn programming language, teachers could now facilitate learning of students by the attractive school-based games, which focus on particular topics the teachers had selected.

Keywords: scratch, mathematics, interactive, primary school, in-service teacher

Introduction

Scratch is a visual programming tools that is widely used in many lessons, it facilitates creative problem solving, logical reasoning and encourage collaborations when the children play with Scratch (Calder, 2010). While many of the lessons use the coding features of Scratch, teachers may also use the interactive features in their lessons. In a course for in-service primary school teachers, on the use of technology for the school-based learning and teaching, teachers had an experience on how Scratch can be used to facilitate learning. Starting from no programming history, teachers spent 3 hours each on 4 topics including Take-Away Model, The Four Operations, Divisibilities, and Area of Simple Figures, via step-by-step procedures on setting up animations within the themes that would attract students, and with the interaction responses such as text and sound, they successfully handled the use of Scratch and could design and make their lessons perfectly to their students.

Conceptual Framework

The conceptual framework of the Interactive Lessons based on the Multi-store Memory Model (see Figure 1). The learners receive information from different channels, normally by means of sounds or texts, such information would enter the Working Memory. While most of the information would be lost within seconds, the learner would “select” some of the information to enter the Long-Term Memory. Sometimes, when there is a need, which is facilitated by the Sensory Memory (in the case of drilling), the Working Memory would actively

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recall the information from the Long-Term Memory, and the previous knowledge from the Long-Term Memory and the newly received information would be articulated and combined to form the new knowledge, such newly formed knowledge would be stored in the Long-Term Memory afterwards.

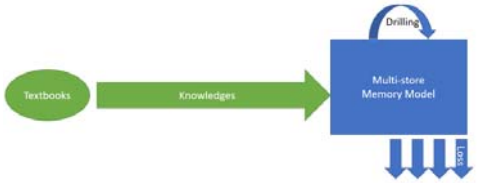

Figure 1. Simplified Multi-store Memory Model.

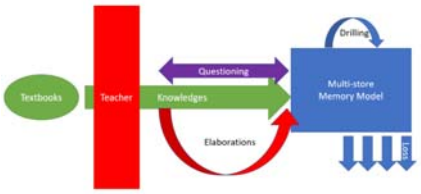

Figure 2. Modified Multi-store Memory Model involving teachers.

With the involvement of teachers, both inside and outside the classrooms, the teachers facilitate better experience for the learners' learning. The teachers could elaborate the texts from the textbooks with manipulatives or even simple blackboard drawings. According to the Dual channel assumptions (Mayer, 2005), the rate of information loss would be lower when the learners receive information through separated sensors.

The questions raised in the lesson would also strengthen the learning. With the questions posed by the teachers (and sometimes by other students, or by the learner himself), the process recalling previous knowledge was simulated. Learners may have better learning experience by drilling as well. Learners would actively recall the knowledge from the Long-Term Memory, and the feedback from the teachers would enhance the learning. The involvement of teachers can be seen in the modified Multi-store Memory Model (see Figure 2).

The roles of Scratch pieces even enrich the modified model (see Figure 3). The Scratch pieces would turn the text and the simple solid illustrations into dynamic cartoons, they would turn drilling and assessments into interesting games, they would also act as teachers outside the first-classroom.

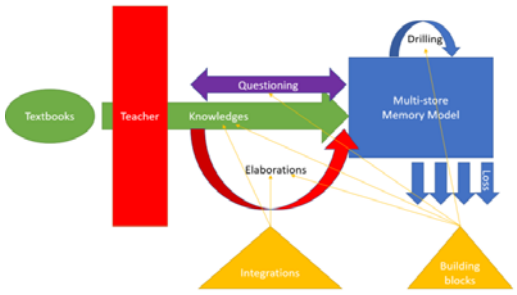

Figure 3. Modified Multi-store Memory Model involving teachers, and the Scratch pieces.

The Use in the First-classroom

In the case of learning in the primary schools, learners could receive knowledge directly from the books, teachers on the other hand could take part in the elaborations of such concepts in the lessons. While the information from the books enters the learners' Sensory Memory in terms of texts and illustrations, the teachers provide audio or sometimes visual input through questioning and the blackboard, the Scratch pieces on the other hand could help teachers delivering the contents not only with the texts and illustrations, but also the animations and the audio means.

The Use in the Third-classroom

In the case of learning afterschool, learners could reinforce their knowledge in the case of drilling. When the learners need to tackle problems, the Working Memory would recall the previous relevant knowledge from the Long-Term Memory, such process would enhance the memorization on the particular topic. With the help of the Scratch pieces, learners could reinforce their learning by the repeating practice of calling back the previous knowledge, the Scratch pieces could facilitate the Active Recalling Process at the third-classroom.

It is possible to re-construct the learners' knowledge. When the learners obtain information related to the previous knowledge, the learners would recall the previous knowledge from the Long-Term Memory, such knowledge would be articulated with the new information and be stored back to the Long-Term Memory. With the help of the Scratch pieces, important information could be delivered at the desired time, this could enhance the re-construction in the learners Long-Term Memory, especially the case when some information was lost during the learning process.

The Use in the Assessment

Traditionally teachers agree that assessment is an important process in learning, Wankat (2001) further suggests that regular homework with immediate feedback would enhance the learning, while teachers could monitor the rough learning progress of learners and to modify the teaching progress, learners could also obtain the pace of their learning, and to check whether the knowledge would be perfectly matched with the core contents with the feedbacks. Scratch pieces could help assessing the learners by means of games, and to provide the mentioned immediate feedback. By the programme designed by the teachers, important information could be delivered at the desired time, no matter it is in the first-classroom, or in the third classroom at home.

Descriptions of the Scratch Pieces

In the course, step-by-step procedures were introduced to the in-service teachers, on creating manipulatives on four topics of elementary Mathematics. Different approaches were applied on the four pieces.

Take-Away Model

The original Take-Away model is a graphical representation of composition of numbers. According to the Curriculum Development Committee (1983), such kind of representation is the preparation for addition and subtraction. The traditional way of delivering this concrete concept to children, is to use the editor-centered graphs in the textbooks, or the time-consuming blackboard drawings with the elaborations of teachers. Clements (2000) claims that dynamic visual representations of the computer support the construction of mathematical ideas, where in this case the Scratch manipulative describes the Take-Away Model by set of apples (where the teachers could change the object to any other kinds within a minute). Assigned number of apples are shown inside the solid-lined region, this number is the number assigned from the teacher according to the progress of the lesson, the assigned number is in turn the Minute in the Mathematics expression. The user could drag-and-drop any apples in (and out) the dotted-lined region inside the original one, Mathematical expression shown in the bottom of the screen would be updated instantly. A new working cycle is facilitated when the character of MC is being clicked on.

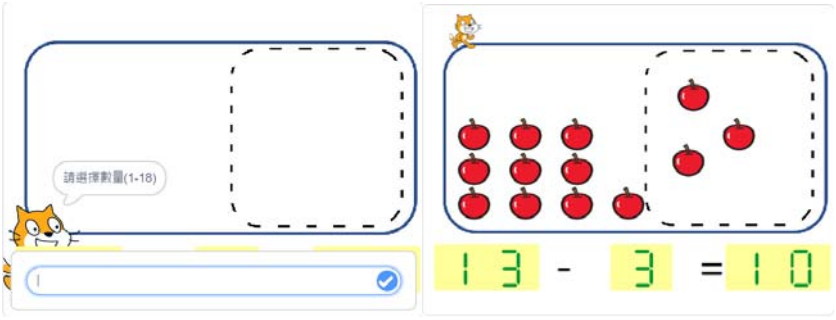

Figure 4. Screen Shots of the Scratch piece Take-Away Model.

The piece is useful in the first-classroom. While the traditional teaching depends on the solid illustrations on publisher-selected examples, teachers could choose and change the scenarios based on their teaching styles, and the progress of the lessons at all time. The dynamic changes of the expression save the time needed for changing the information on the blackboard of the traditional lessons, such expression appearing at the bottom of the visual representation, as an aid near the corresponding parts of graphics, also help to reduce the cognitive load as named spatial contiguity effect by Mayer (2002).

The Four Operations

The manipulative is themed as a simplified baseball game. The player has to key-in the correct number for the question mark in the expression such as “8×?=48”. Different audio effect would be provided depends on the inputs of the player.

Drilling is a way to enhance memorizations of different contents, it reduces the Cognitive Load of the learners. The major help of the Scratch piece is to change the boring drilling tasks in the workbooks into encouraging video games: Schuetz, Biancarosa and Goode (2018) conclude that students in the traditional classrooms were more reliant on the help of the teachers, the instant feedback from the Scratch piece help building up independent learners, which contributes towards the learning motivations.

Computer games encourage active learning (Ahmad and Jaafar, 2012). With the Scratch piece, drilling could be more interesting than you may think. Once the learners start the Scratch piece, they pretend they are the audience of a baseball match, with the background taken out from a video game on baseball. The players control the successfulness of the batsmen, by entering the correct answer to the Mathematics expressions. The instant sound effect with the changes of the score encourage learners to achieve, this would increase the motivation of playing such game, which would in fact increase the frequency of loading previous knowledge from the Long-Term Memory, thus decrease the Cognitive Load of the learners.

Figure 5. Screen Shot of the Scratch piece The Four Operations.

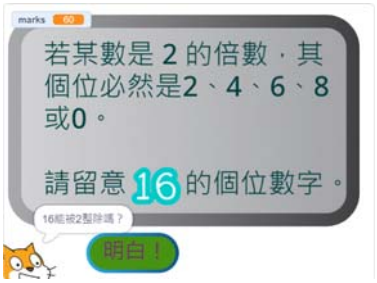

Figure 6. Screen Shots of the Scratch piece Divisibilities.

Divisibilities

The manipulative shows a number ranged 10 to 99, the character of MC asks whether the number is divisible by 2, 3, 5 or 10 randomly. A dialog of hints on the divisibilities would be popped up when the player needs it. A visual response would be given depends on the inputs of the player. Eason and Ramani (2020) claim that guided learning in a formal class facilitates learning, they also claim trained parents could facilitate the learning as well. Scratch piece of Divisibilities could provide instant guide to the learners who are facing difficulties in solving the problem, and to decrease the Cognitive Load of the learners. Even though Razzaq and Heffernan (2010) argue that hints may have different effects on learning, teachers could actually adjust the outcome of clicking the button, such as deducting marks directly, according to the believes of the teachers.

The time is limited in all the classrooms, so the teachers could modify among the parts of the game, in order to help learners of different status. The level of the game, that is the range of the detecting number could be adjusted, for learners with different learning needs. The potential factor (as well as the frequency of appearance) could be adjusted based on the teaching progress of the first-classroom. The changing scores of the correctness could be adjusted based on the purpose of playing.

Area of Simple Figures

The manipulative consists of a spaceship in the space. A formula is shown in the bottom of the screen, the player has to control the spaceship by the arrows in the keyboard, with the shooting function facilitated by spacebar. The player has to match the given formula to the name of shape, special audio and visual effects would be shown.

Figure 7. Screen Shot of the Scratch piece Area of Simple Figures.

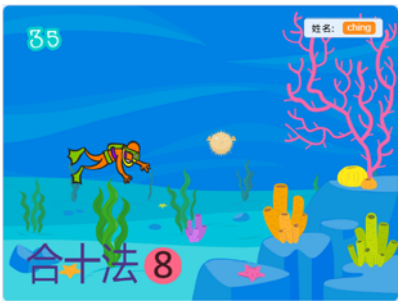

Figure 8. Scratch piece demonstrating the idea of Making Ten.

Assessment is an important process of learning. With the Scratch piece, the learner could evaluate the achievement of learning in the particular topic (in this case Area of Simple Figures). The Scratch piece provides instant feedbacks to the learners, these easy non-informative feedbacks point out the achievements of the learners.Just like the previous Scratch pieces, these features facilitate better learning experience of ones.

Results and Discussion

The in-service teachers have developed their own Scratch pieces for their students, some of them set up cartoons to demonstrate topics in their own teaching styles; some of them develop guided examples or assessment tasks with hints for the students to work on after school; some of them make games for students in particular with special learning needs. A few examples could be seen as below:

Demonstrating Topics

With only the textbooks or the publisher-centered electronic resources, teachers could rarely deliver the contents as the raw concepts in their mind. But the participants of the course could now write a Scratch piece for the demonstration uses. The idea of Making Ten, a technique we always use in addition, can now visually appeared in front of the learners.

Guided Examples

During the teaching in a classroom, catering learning difference is always a difficult task for teachers. With the colourful Scratch piece of a participant, students could re-visit the examples with additional practice at home. Such Scratch piece is especially useful when the teachers and the students could not physically meet the others.

Figure 9. Scratch piece of particular examples with guided addition practice.

Figure 10. Scratch piece of assessment.

Assessment Tasks

Answers of many elementary Mathematics could be easy to obtain, yet the teachers are not free to mark the assignmentsevery second. The Scratch piece of another participant could provide the real time instant result of assessment to students. Meanwhile the learners would drive themselves to practice until getting a “good” result, as there are no such attempt limitations to them. The outputs of the Scratch piece also provide the basic information such as the name of the learner and the spending time for different parties to review.

There are many concrete-abstract idea in Mathematics, with the use of Scratch pieces, teachers as well as the students could keep the pace of learning. A participant makes a Scratch piece to help learners checking on theit own learning pace, this would help learners making clear about the objective of the topics, in particular three dimension figures in the example shown in Figure 11.

Figure 11. Scratch piece for monitoring the learning paces.

Conclusion

While teachers suggest learning should be extended to the second and the third classroom, with this easy-to-learn programming language, teachers could now facilitate learning of students by the attractive school-based games, which focus on particular topics the teachers had selected while different parties could make good use of the learning pace determined by the Scratch piece.

Teachers in different places might use different platform to facilitate the learning of the learners, yet Scratch is easy to use for thousands of teachers with no programming history.

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