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The impact of sensory simulations on young children's science learning

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Abstract: Simulation was found to be an effective tool for learners to learn science. However, young children might have difficulty to integrate their understanding and the simulation because of inability to process virtual and abstract information. This study proposed a sensory simulation which helps young children learn science. The results show that the sensory simulation help the young children assimilation the concept and reflect in some questions while it did not enhance learning in other questions. More qualitative interview data should be collected to understand the cognitive process of using sensory simulation.

Keywords: primary school students, science simulation, science education, conceptual understanding

1. Introduction

Previous studies have shown that simulations (or virtual laboratory) could be the integrative tools for science inquiry. It has been found that computer simulations facilitate higher cognitive skills (Lin et al., 2014) such as modeling performance (Wen et al., 2018). However, it is a controversial issue that whether simulations help young children learn science. Some studies found that simulations enhance primary students' learning performance, and improve their perceptions about science inquiry (Sun, K. T., Lin, Y. C., & Yu, C. J. , 2008; Unlu, Z. K., & Dokme, I., 2011). Conversely, students simply view the result as the other facts which is different from their experience of life and did not integrate the simulation with their prior understanding (Jaakkola, T., & Nurmi, S., 2008).

It might be because young children might lack the experience in processing virtual and abstract information given by the simulations. To address this issue, it is indicated in the literature that embodied cognition have positive influence on learning. Embodied interaction enhances the effectively reflect and rethink the core concept (Lindgren, Tscholl, 2016). Sensory simulations, which strengthens students' physical or sensory sense of the simulated phenomena based on users' cognitive level, were shown to help learners construct solid cognitive grounding (Zacharia, 2015).

Nevertheless, few studies have examined how sensory simulations help young children learn science. Therefore, this study proposed a sensory simulation design for primary school students and discovered the influence of different simulation design on young children's science learning. The research question is how primary school students improve their conceptual understanding after using the sensory simulation?

2. Method

2.1 Participants

The participants of this study were 75 5-grade students from two primary schools. None of them reported experiencing of using simulations in science learning. There were 34 students in the control group who were from two classes in a school. The other 41 students in the experimental group were from two classes of another school. Two to three students were teamed up randomly and seated nearby in a traditional classroom. They were encouraged to discuss with each other and equipped with an iPad to operate the simulation collaboratively.

2.2 Procedure

The learning activity of the two groups was implemented in a 90-minute session. Pre-test and post-test were conducted in the first and the last 10 minutes. After taking the pre-test, the students were instructed to understand the context of the simulation for 5 minutes. Each student was given a worksheet which guided them to predict, collect and record data, make conclusions with teammates. A whole class reflection activity was led by the teacher after they concluded their findings. All the students were asked to present their conclusions and discussed with the teacher and the student peers. After that, they were asked to apply their findings in an application pen-ended questions on the worksheet. The learning activity and the discussion lasted for 65 minutes.

2.3 Simulation Designs

The simulations were developed based on the platform CoSci (https://cosci.tw) (Chang et al., 2017), which provides scientists and teachers to create simulations by a graphic user interface. To discover how the simulations influence young children's conceptual understanding, this study developed two types of simulation design: conceptual simulation and sensory simulation. The conceptual simulation composed of the graphic representations for students to learn the concept of the target science phenomenon. The sensory simulation is designed based on a representation that is sensible for the cognitive level of the target students. This study designed both simulations to simulate a problem: whether an individual will get less wet or not if he/she run faster from place m to place n in the rain. The students were guided to manipulate the velocity of the character and observe the top rain, the side rain, and the relationship between the total rain and the top and side rain volume.

2.3.1 Conceptual Simulation

The conceptual simulation shown as Figure 1 below were used by control group (CS group). The top, side and total rain accumulated with different running velocity were dynamically displayed in different bar charts respectively to help students to compare and learn whether the running velocity influence the top, side and total rain volume falling onto the man.

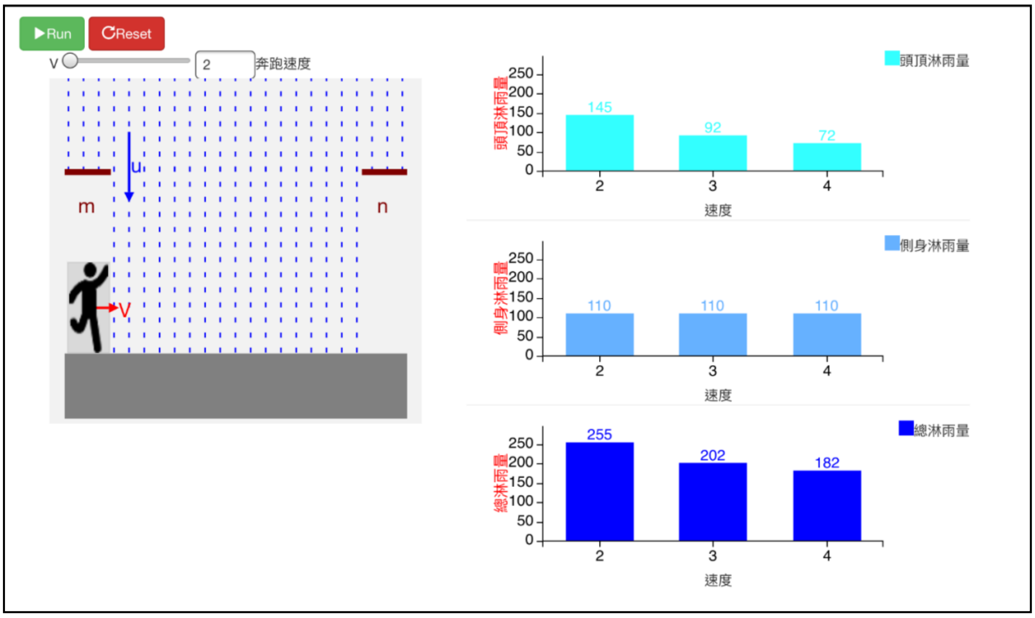

Fig 1. Conceptual simulation design

2.3.2 Sensory Simulation

The sensory simulation, shown in Figure 2, is composed of the bar charts, the animations and the slider for students to manipulate the running velocity. Different from the conceptual simulation, the animation adopts a sensory representation, displaying the rain in a form of countable raindrops, so that students can measure the rain volume by counting the raindrops falling onto the top and the side surfaces of the yellow box. The charts of the rain volume on the right side will also change according to the raindrops received by the yellow box. The students in the experimental group (SS group), were asked to count the number of the rain drops. It was expected that such sensory simulation would improve young children's conceptual understanding.

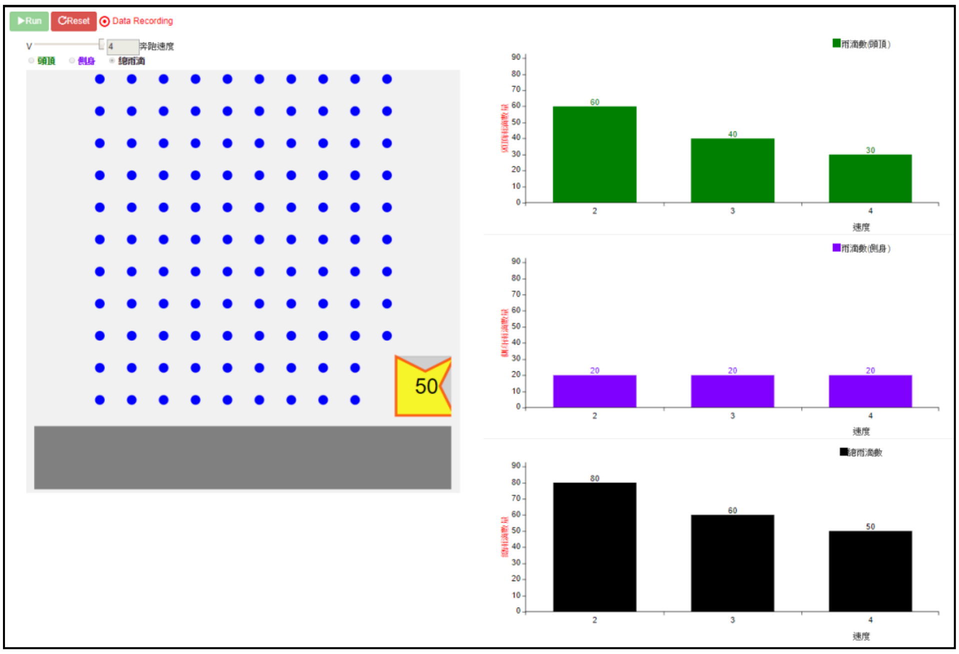

Fig 2. Sensory simulation design

2.3.3 Data Collect and Analysis

To discover how the simulation influences young children's learning, the pre-, post-test and the worksheet were collected. The pre- and post-test were both composed of two open-ended questions, one of them is a similar context about side rain and the other one is about top rain. For instance, the top rain question is: A man holding an empty cup went through the rain. Whether the man run or walk slowly will get more water in the cup? Between the pre- and post-test, students work in pairs collaboratively on a worksheet to answer two similar questions.

The students' answers of opened-ended questions were rated by two of the researchers. The rubrics is listed as Table 1 below. The inter-rater reliability is xx for pre-test, worksheet and post-test respectively, indicating acceptable reliability.

Table 1. Rater rubrics

Score	Description	Example
0	Blank or wrong answer.	**<u>Top</u>** - No matter the velocity, the accumulated rain would be the same. Because that there are same rain volume in place A (origin) and in the place B (destination). **<u>Side</u>** - Run faster would get wetter, because that when the bus drive faster, the speed of wind would get faster.

1	Correct answer without explanation	**Top** - Slow. Slower would get more accumulated top rain. **Side** - The accumulated rain would be the same. No matter the velocity, the accumulated rain would be the same.
2	Correct answer and describe the explanation the life experience or simulation results.	**Top** - Slow. It is just like the accumulated top rain. **Side** - Run or not the accumulated rain volume would be same. Because the running velocity would not influence the accumulated side rain volume.
3	Correct answer and describe the correct reason.	**Top** - Slow. Because run slowly would lead to be more time in the rain, the object would get more rain. **Side** - Run fast or slow would be the same. Because the distance is the same.
4	Correct answer and give the correct explanation by life experience or	**Top** - Run slowly. Because the time in the rain would be lasted longer, and the accumulated top rain volume would increase also. **Side** - None of students got 4 points.

3. Results

3.1 Conceptual Change Process of both group

The figure 3 and 4 show how the simulation influences primary school students' understanding of the target phenomenon. The numbers in the circle represent how many persons achieved a specific score. The line connected between two circles represent how many students change from one score to another along with the pre-test, worksheet and post-test.

Figure 3 displays the two group students' conceptual understanding of top rain. As indicated in Figure 3, only a few CS students improved their conceptual understanding to 3 point in the worksheet (5 students, 11%) and the post-test (11 students, 32%). On the contrary, more SS students got more than 3 point in the worksheet (16 students, 39%) and the post-test (17 students, 41%).

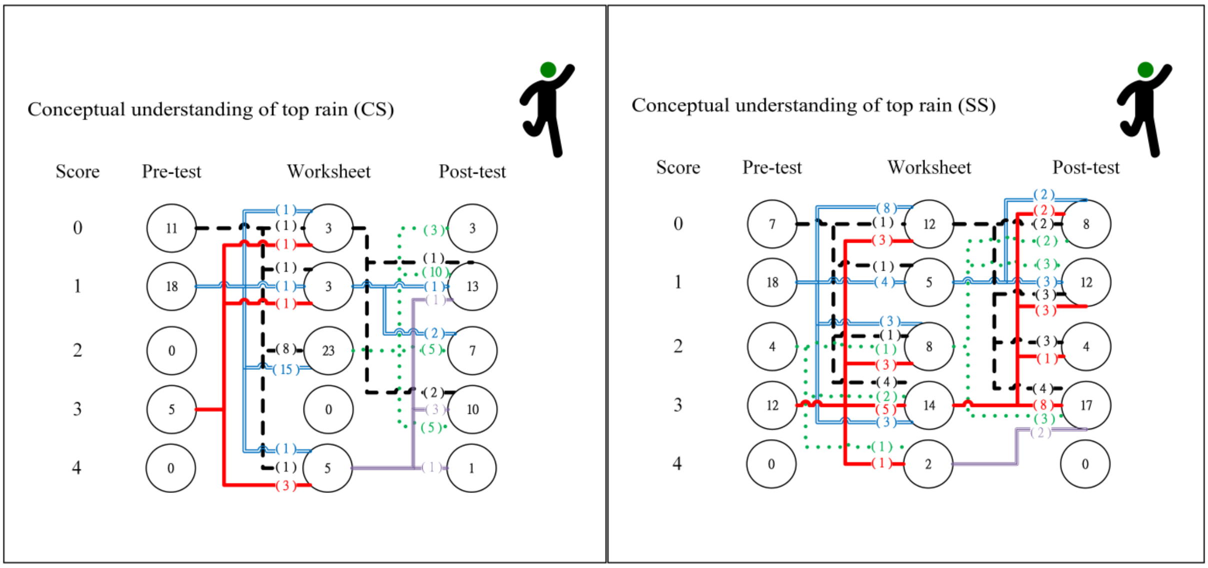

Fig 3. The CS and SS students' conceptual understanding of top rain.

The figure 4 presents the conceptual understanding of the side rain of the two groups. In the two groups, most of students (32 students, 94% in the CS group; 40 students, 98% in the SS group) got 0 point in the pre-test. However, in the worksheet, half of students (16 students, 47% in the CS group; 17 students, 41% in the SS group) got 2 points, the other half students still got 0 point after the learning activity. In the post-test, most of the students performed similar to what they did in the post-test. Notably, only one students in the SS group reported the distance would affect the side rain volume accumulated, but the velocity wouldn't affect it.

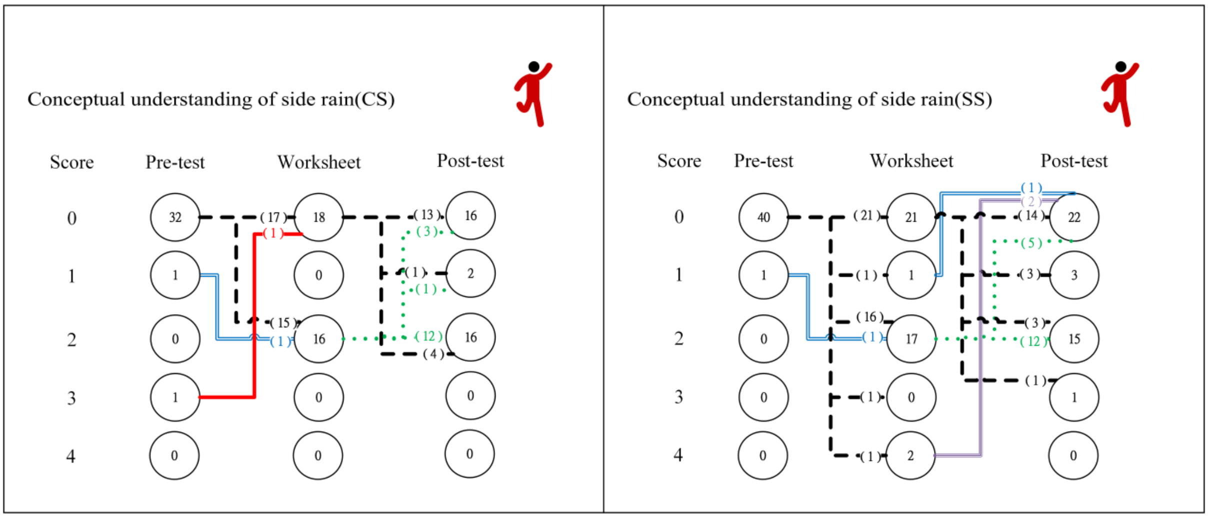

Fig 4. The CS and SS students' conceptual understanding of side rain.

4. Discussion and Conclusion

This study proposed a new simulation design and investigated how the simulation would influence primary school students' conceptual understanding. This study found that the sensory simulation facilitates the young children's conceptual understanding in the top rain question.

Because the side rain problem deviates from the life experience of the students, both SS and CS group did not perform well in this question. However, more SS students could scientifically explain the target phenomenon than the CS students did. It was indicated that the CS group students who used the conceptual simulation tended to only memorize the result of the simulation. It is aligned with the previous study that students tend to separate their experience in using the simulation and their existing understanding of the world. In other words, they can understand the concept represented by the simulation. However, they do not necessarily integrate the simulation with their existing understanding of the problem (Jaakkola, T., & Nurmi, S., 2008). However, this study found that the SS group students could observe and analyze the result of the simulation to understand the phenomenon on the top rain question. Such findings suggest that sensory simulation might help young children to understand the meaning of the information presented in the simulation. Future studies may be necessary to integrate more qualitative interview to understand the cognitive process when students are using the two simulations.

Acknowledgements

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