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Mathematics and Science Teacher's Conception and Reflection on Computer Programming with Scratch: Technological and Pedagogical Standpoint

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Abstract

The current study investigates teachers' conception and reflection of computer programming from scratch in terms of technological and pedagogical standpoint. Mixed research approaches typically achievement tests and interviews were used to collect quantitative and qualitative data respectively. A total of twenty-one Mathematics and Science teachers were randomly selected to participate in the study. A paired t-test was used to analyze quantitative data from pre and post-test, while descriptive and interpretive analyses were used to analyze qualitative data from the interview. The results of the study showed that Mathematic and Sciences teachers have a great conception of scratch programming after attending scratch programming. There was a significant difference in mean between pre and post-test ($p < 0.05$). It was also found that scratch is an effective pedagogical tool for teaching and learning Mathematics and Sciences. In addition, teachers expressed positive views of using scratch in teaching and learning Mathematics and Sciences as it helps them to visualize abstract content, motivate students, increase students' interest, critical thinking, and problem-solving skills, act as an assessment tool and increase student's academic performance.

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1. Introduction

Computer programming succeeded to boost most of the aspects of our society, respond people's needs, and being adaptable to modern and future technology (Kalelioglu & Gülbahar, 2014). Using computer programming increase the computational thinking of students (Saltan & Kara, 2016). Teachers at different levels and from different subjects use computer programming to improve teaching-learning and help students to develop skills (Ferrer-Mico, Prats-Fernàndez, & Redo-Sanchez, 2012). Scratch is a highly versatile tool that facilitates the teaching of abstract concepts in any subject (Naz, Lu, Zackoski, & Dingus, 2017). Scratch is a tool that Mathematics and science teachers can use to visualize and supplement their teaching. Programming via scratch was found among methods that were used to elaborate scientific concepts (Weigend, 2014). Scratch creates educational and entertaining content, simulates and visualize mathematically, and visualizes the concept. Scratch improves students' digital literacy, imagination, and creativity, internalizes knowledge, promotes critical thinking, and solves complex problems (Uzunboylu, Kınık, & Kanbul, 2017).

Scratch has a positive impact on teaching mathematics and sciences. The study conducted by Noftiana, Nasir, and Islami (2019) showed that using scratch during teaching physics helps students to understand electric dynamics and students are interested in scratch animation. It was found that scratch helps the students to test themselves physics concepts and enable them to understand well physics (Svensson, Eriksson, & Pendrill, 2020). (Weber & Wilhelm, 2020) showed that the use of programming in physics education has a positive impact on students' conceptual understanding, critical thinking, and increase interest in physics. Scratch is a useful tool that helps the students to deal with challenging mathematical concepts (Benton, Saunders, Kalas, Hoyles, & Noss, 2018). It was found that scratch is an environment that has allowed mathematics subject to become more interesting to students while learning geometry (Iskrenovic-Momcilovic,

2020). It was expressed that linear function, quadratic equation and exponential function became easier when are taught by using scratch. The study conducted by Kim, Choi, and Paik (2019) showed that a scratch is a useful tool in teaching the Bronsted – lowry acid-base model.

2. Research Questions

1. What is the teacher's knowledge toward the utilization of scratch as a pedagogical tool in teaching and learning mathematics and sciences?
2. How do teachers reflect on the usefulness of scratch in teaching and learning mathematics and sciences?
3. What are teachers' perceptions towards the utilization of scratch as pedagogical too in teaching Mathematics and Sciences?

3. Hypothesis

Ho: Teachers have no great conception in programming with scratch after the course than before.
H1: Teachers have a great conception of programming with scratch after the course than before.

4. Methodology

4.1. Research Design

This study follows mixed research whereby quantitative and qualitative methods were used to collect and analyze them. A mixed research design is useful because it uses the strength of both quantitative and qualitative data and helps the researcher to gain insight from a combination of both quantitative and qualitative data than either one itself (Boman et al., 2017). A mixed research design also helps the researcher to laborate and clarify the results from one method with the findings from the other method (Molina-Azorin, 2016). The data were collected in phases (sequential design) whereby the researcher started with a pre-test to see teacher's prior knowledge before training. Thereafter, the post-test was also used to check whether the teachers knowledge was increased. The interview was used to gain teachers' reflections after training and usefulness of scratch in teaching and learning mathematics and sciences.

4.2. Population

A population is a set group of all units in which research findings need to be applied (Casteel & Bridier, 2021). Thus, the population of this study was all Mathematics and Sciences teachers from the following subjects including Mathematics, Chemistry, Biology, and Physics in ordinary level in kayonza district, East province, Rwanda.

4.3. Sample and Sampling Procedure

The sample is representative of the population (Taherdoost., 2018). According to Gowda et al. (2019) sample is more than being representative of the population but also saves time and produces more accurate results. The sample of the study was twenty-one teachers of Mathematics, Chemistry, Biology, and Physics from the ordinary level in Kayonza district, Rwanda selected randomly.. Random sampling is useful because all participants have an equal chance to participate in the study (Taherdoost, 2016).

4.4. Instruments

4.4.1. Achievement Test

The test can be used to determine the level of understanding of knowledge and concepts (Sener & Tas, 2017). In this study, both pre and post-test were used to collect data. A pre-test was used to test the teacher's prior knowledge before attending scratch training while a post-test was used to test whether the teacher's knowledge on scratch was increased after attending training of scratch in teaching and learning Mathematics and Sciences. All pre and post-test were criterion-referenced and marked out of twenty marks.

4.4.2. Interview

An interview is a tool used to gain the personal view, opinions, and feelings of participants (Alshenqeeti, 2014). In this study, the interview was used to explore teachers' reflections after attending scratch training its usefulness in teaching and learning Mathematics and Sciences.

4.4.3. Data Analysis

Both quantitative and qualitative analyses were used to analyze data. Quantitative data were analyzed by using descriptive and inferential statistics whereby descriptive analysis such as mean, maximum, minimum, and standard deviation was calculated. On the other handthe inferential statistics paired t-test and Spearman correlation were used. Paired t-test compares the mean of a single group, examined at two different points in time (Allen, 2017). Paired t-test was used to compare the mean performance before training and after training at a confidence level of 95%. By using the paired sample t-test, we can statistically conclude whether or not training has increased teachers' knowledge or conception from scratch. Qualitative data were analyzed

by using interpretive analysis. The interpretive analysis helps the researcher to gain insight into how participants experience a given phenomenon (Alase, 2017).

4.5. Reliability and Validity

The validity of the research is to measure what is supposed to measure (Sarrigeorgidis & Rabaey, 2003). To ensure content validity,the research instruments, interview guide, and achievement test were checked and approved by the expert in the research education from the University of Rwanda, College of Education (UR-CE). Their comments and recommendation were helpful and constructive to improve the final research instruments. Reliability is concerned with the consistency, stability, and repeatability of the information (Bapir, 2012). To ensure the reliability of the study, test items were piloted to eight ordinary chemistry teachers. To ensure the internal consistency of test items, a reliability coefficient was used by using the Split-Half reliability method. Two groups of teachers were created, each group was composed of four, and achievement test items were separated into halves. One group did odd questions while the other group did even questions. The reliability coefficient between the two groups was calculated and found to be 0.81 which is high.

4.6. Ethical Issues

The researcher obtained research permission from the educational administrator and the participants have explained the purpose of the study. All participants agreed to sign consent and to participate in the research voluntarily. The principle of anonymity and confidentiality were respected.

5. Results and Discussion

5.1. Teacher's Knowledge about the Usage of Scratch in Teaching and Learning Mathematics and Sciences

This section report teacher's score of pre and post-test. Table 1 & 2 show descriptive and inferential analysis. Test were practicals and scores were measured out of twenty marks.

The result in Table 1 shows the mean score was 12.52 with 1.21 standard deviation in pre-test and increased to 17.39 with a 1.43 standard deviation in post-test. The maximum score was 15 in the pre-test and increased to 20 in the post-test. The minimum score was 12 in the pre-test and was increased to 15 in the post-test. The results of paired t-test showed that there is a highly statistically significant difference between pre and post-test (df =20, p = 0.000). therefore, the probability value (p) of difference was small than expected 0.05(confidence level of 95%). therefore, the results showed that teachers have great conception using scratch in teaching Mathematics and Science after attending scratch training. The correlation analysis of pre-and post-test in Table 2 found that there is a positive correlation of 0.515 after attending scratch training.

Table 1. Descriptive and inferential analysis of pre and post-test.

Achievement test	Mean	Std. Deviation	Min	Max	P
Pre-test	12.52	1.21	12	15	0.000
Post-test	17.39	1.43	15	20	

Table 2. Correlational analysis of pre-and post-test.

Achievement test	N	Correlation	Sig.
Pre-test & Post-test	21	0.515	0.017

The above results are in agreement with other authors. Sáez-López, del Olmo-Muñoz, González-Calero, and Cózar-Gutiérrez (2020) found that there is a significant difference in pre-service teachers' conception after attending scratch training. Concerning (Iskrenovic-Momcilovic, 2020) showed that the use of scratch has a positive correlation with the students' overall school performance and shows that there are no differences in achievement between boys and girls. This was also supported by García-Gutierrez and Hijón-Neira (2020) showed scratch has a positive and significant degree of teaching and learning. Scratch is an environment that has allowed mathematics to become more interesting and interesting to students. According to Budak, Geçer, and Topal (2021) found that using scratch has a positive impact compared to other teaching methods.

In addition, to investigate teachers' conception of programming with a scratch in teaching Mathematics and Sciences during training sessions teachers develop mathematics and science scratch projects based on the subject they tough (Mathematics, Chemistry, Biology, and Physics). The two best-selected projects are chemistry and physics projects. The link and screenshot of the developed project are found below.

A sample of a project designed by a chemistry teacher (water cycle): link of the project is https://scratch.mit.edu/projects/600905581/ and screen show in Figure 1.

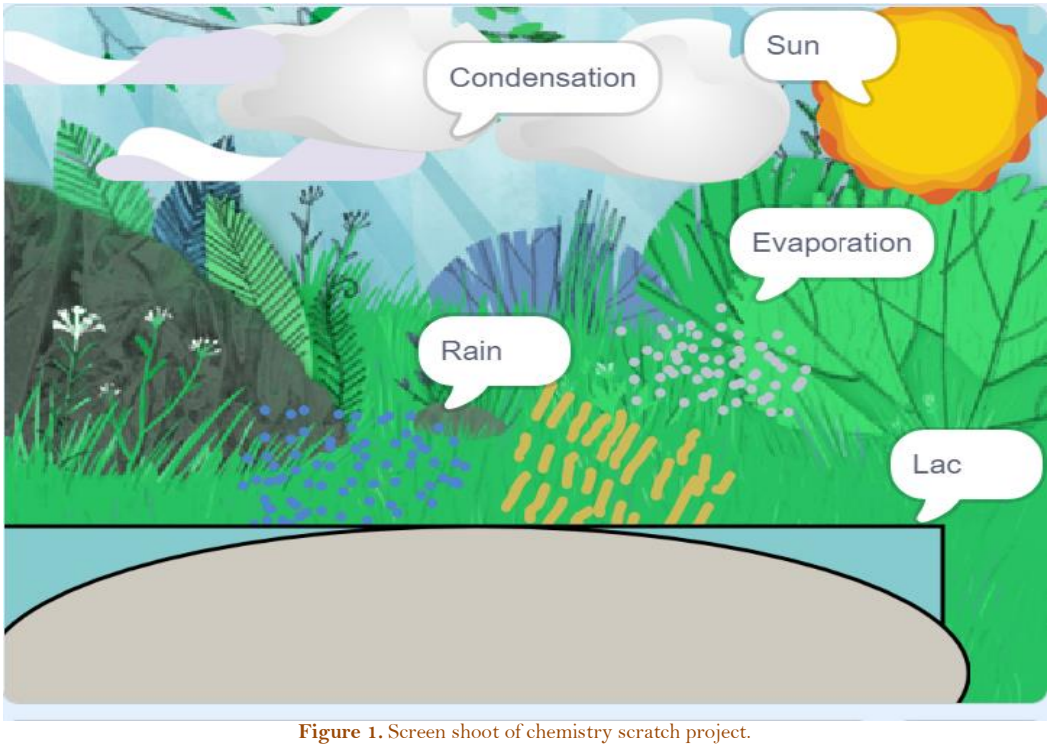

Figure 1. Screen shoot of chemistry scratch project.

A sample of the physics project (newton law), the link is https://scratch.mit.edu/projects/631667157/, and the screen shoot in Figure 2.

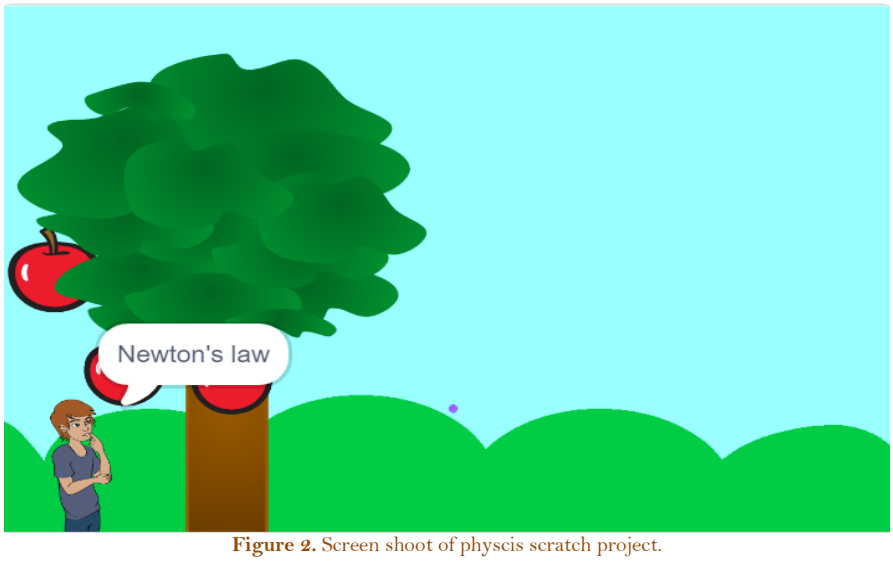

Figure 2. Screen shoot of physcis scratch project.

5.2. Teacher's Reflection on the Usefulness of Scratch as A Pedagogical Tool in Teaching and Learning Mathematics and Sciences.

To explore teachers' reflections on the usefulness of scratch as a pedagogical tool in teaching and learning Mathematics and Sciences incorporation of teacher's ideas and views were used from the interview. The interview guide was composed of two open questions see (Box 1). To respect the confidentiality of participants The following coded to name teachers T 01 up to T 21 were used.

Box 1

- Is scratch a suitable teaching tool for teaching Mathematics and Sciences? How
- Are you ready to use scratch in your future teaching? If yes, what will help you to improve?
- In your view, what are the importance of scratch in teaching and learning Mathematics and Sciences towards students' understanding?

All interviewed teachers (100%) agreed that a scratch is a useful tool in teaching Mathematics and Sciences. The reasons are: T 004 said that*" through scratch programming, my improvisation ability was increased*". Another teacher explained that" *through Scratch programming, my ability to create content that can increase students' interest and motivation has improved*" T 16. T 008 reported that scratch helped him to create animation for effective teaching biology concepts. Seven teachers T 01, T 13, T 06, T 11, T 18, T 05 & T 19 said that" *scratch is a suitable tool in teaching and learning Mathematics and Science because it develops critical thinking skills*". T 15 said that "*scratch is suitable too for visualizing abstract concept". Scratch is a suitable assessment tool in Mathematics and Sciences.* T 02 said. From the above teachers' ideas, it was found a scratch is a suitable tool in teaching Mathematics and Science as it helps teachers to create digital content, increase students' interest and motivation, create animation, assess content, visualize abstract content and develop critical thinking of students. All interviewed teachers 100% agreed that they were going to integrate scratch in their teaching and believed that it will help them to improve their learning. One teacher T007 said that" *scratch will help me to improve the mode of assessment".* Another teacher (biology teacher) T14 said that "*scratch will help me to improve my teaching through representing abstract concepts*". A teacher of chemistry reported that" *through programming with scratch, I'm ready to create my animation"*(T003) said. Incorporation of teachers' ideas was used to investigate the importance of scratch towards students' conceptual understanding of Mathematics and Science. Teachers reported that scratch is useful in teaching and learning Mathematics and Sciences as it can help them in the following ways: motivate students to learn and love Mathematics and Sciences, increases student's critical thinking skills and performance, prompt problem-solving skills of students, and helps students to understand abstract content.

The above results are in agreement with Saltan and Kara (2016) found that pre-service teachers have a positive perception and agreed that scratch is easy to use in teaching mathematics. The study conducted by Choi (2013) on Korean pre-service teachers revealed that teachers have the great intention of using scratch in future teaching. According to Fagerlund, Häkkinen, Vesisenaho, and Viiri (2021) found that programming with scratch increases computational thinking and problem-solving skills. In addition, the use of scratch programming increases students' conceptual understanding of content (Noftiana et al., 2019). Regarding (Gutiérrez & Zapatera Llinares, 2021) found that scratch act as a demonstration method, cooperative learning and gamification, and assessment tool in teaching line function and quadratic function. Scratch also is a motivational tool and help the teacher to deliver lesson step by step to visualize concept (Weigend, 2014).

6. Conclusion

The present study tended to explore teachers' conception and reflection of computer programming with a scratch in teaching and learning Mathematics and Sciences. The results of the study showed that programming with scratch has a positive impact on teaching Mathematics and Sciences. A paired t-test analysis showed that there is a significant statistical difference in teachers' scores after attending scratch training. Mathematics and science teachers' scratch projects showed that scratch is an effective pedagogical tool in teaching Mathematics and Sciences. Interview results revealed that scratch increases students' interest and motivation, develops students' critical thinking, visualizes the abstract concept, acts as an assessment tool, increases students' performance and problem-solving skills.

7. Future Consideration

The study found interesting results. However, the sample was small. The researcher recommends future studies cover a big sample. Future studies are needed to investigate the effectiveness of scratch towards students' conceptual understanding and academic performance compared to the other teaching methods. Future work will explore students' conception of programming with scratch with control and experimental group.

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