Effects of Plugged-in Chemistry Experiment Moduleon Students' Computational Thinking and Science Process Skills in Chemistry Education

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Abstract. This study investigates the effects of plugged-in chemistry experiment module on students' computational thinking and science process skills. A quasi-experimental design with pre-test and post-test control group was adopted, involving treatment and control groups. Descriptive and inferential analyses showed a significant difference in computational thinking skills between students using the plugged-in approach and those using the conventional approach, favouring plugged-in approach. Conversely, a significant difference in science process skills was observed, favouring the conventional approach. Significant differences were also observed between pre-test and post-test scores in science process skills for both groups, and in computational thinking skills for the experimental group. Lastly, there is no correlation between computational thinking and science process skills among chemistry students. The results are beneficial to the students as they are effective in enhancing students' computational thinking and science process skills.

Keywords: plugged-in, chemistry experiment, computational thinking skills, science processskills

1 Introduction

In the 21st century, students must have knowledge and skills such as higher-order thinking, problem-solving, critical thinking, and creativity to meet current employment demands [1]. Not only that, technology skills are also very important as they play a fundamental role in the 4th industrial revolution, as suggested by various literature[2]. Therefore, technology integration has been extensively used in education to introduce students to software or applications and develop necessary skills. According to the Malaysia Ministry of Education [3], technology integration is encouraged as it brings a positive impact and can be used as a supporting tool to enhance students' problem-solving and creative thinking skills.

There are a variety of educational software that can help students enhance their computational thinking skills. Through the development of computational thinking in education, students will be able to equip themselves with the skills required to tackle complex real-life problems, adapt quickly to new applications or software, and apply these skills beyond the classroom [4, 5]. This essential skill can be developed by using software that involves coding or programming processes. Recognising this need, primary schools have introduced coding into the Information Communication Technology (ICT) curriculum to support students in developing problem-solving skills through computational thinking. This emphasis shows the

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importance of computational thinking, as it is highlighted as an important element in the Secondary School Standard-based Curriculum (KSSM) that can bring a positive impact on students' educational development.

In addition to computational thinking, another important element that has been emphasised in KSSM is scientific skills. These skills, which include science process skills and manipulative skills, are necessary for decision-making processes as well as systematic problem-solving. Science process skills can be developed by carrying out laboratory experiment [6, 7]. For instance, the chemistry curriculum at secondary schools emphasises the laboratory experiments to enhance students' scientific skills, where both science process skills and manipulative skills being evaluated during the Malaysian Certificate of Education (SPM). Since both science process skills and computational thinking skills are highlighted in the chemistry curriculum specification, it is important to implement educational technology in chemistry experiments to further enhance these skills.

Chemistry laboratory experiments are crucial for achieving the aim of the chemistry curriculum such as scientific knowledge, skills, attitudes, and values enhancement [6]. These experiments involve hands-on activities where students interact with and manipulate physical objects, leading to the development of practical skills. As experimental activities are linked to real-world phenomena, students can construct complex scientific knowledge and retain it in long-term memory. Despite the benefits of laboratory experiments, it is undeniable that several challenges may exist in conventional chemistry experiments activities, such as exposure to harmful chemical substances, breaking of glassware apparatus, students merely following lab manuals, time constraint and insufficient equipment [8-11].

Rapid development of technology plays an important role to address the challenges that exist in conventional chemistry experiments and support chemistry learning. While hands-on laboratory experiments are very effective in developing scientific skills, technology-based experiments can offer several advantages, including a safer environment, the ability for students to conduct experiments individually, flexibility in time of time, location and frequency of access, as well as increased student engagement in the learning process [12]. Recent research has explored the effects of technology, but there is a lack of studies examining the effect of technology that use programming in chemistry experiments. While computational thinking skills are recognised as crucial, most research on the effect of technology has focused on virtual experiments rather than those incorporating programming. Technology that integrates programming has the potential to enhance both computational thinking skills and science process skills. Therefore, this study aims to investigate the effects of a plugged-in chemistry experiment module on students' computational thinking and science process skills in chemistry education. This study will test three hypotheses which are as follows:

H_{01}: There is no significant difference in computational thinking skills between students who use the plugged-in chemistry experiment approach and those who use the conventional approach.

H_{02}: There is no significant difference in science process skills between students who use the plugged-in chemistry experiment approach and those who use the conventional approach.

H_{03}: There is no correlation between computational thinking skills and science process skills among chemistry students.

Through this study, effective learning can be achieved as students is fully engaged in the learning process. Additionally, teachers will be able to identify the effectiveness of using programming software in the learning process, which can subsequently be used in other chemistry topics or subjects.

2 Literature Review

2.1 Chemistry Experiment

Scientific investigations or experiments are important activities that must be carried out during chemistry classes. They are essential for students to develop the necessary 21st-century skills, such as scientific skills and thinking skills [3]. The Implementation of Secondary School Standard-based Curriculum (KSSM) requires students to carefully plan scientific investigations and procedures for physical chemistry experiment [13]. With this requirement, students can learn to validate and confirm the concept learned during chemistry class through the experience of handling the materials and apparatus directly, as well as analysing results obtained based on chemistry theories that they have previously learned [14]. Aside from that, the skills acquired such as experimental planning, communication skills, data analysis and team working are transferrable and applicable across different disciplines. Through the inquiry-based approach, students can develop scientific skills, including science process skills and manipulative skills, as well as thinking skills which are necessary for decision making [15].

While conventional chemistry experiments offer many benefits, several problems may hinder students from fully acquiring these advantages. Chemistry experiments involve the use of chemicals and glassware apparatus where students are exposed to harmful chemical substances when certain chemistry experiment is conducted [9, 11]. This is dangerous as students could be exposed to hazard and risks such as gas leaks, infections, hot objects, broken glassware apparatus, release of poisonous gas and chemical reagents that can be harmful to human and environment. Lack of facilities and equipments, such as materials and apparatus that are necessary to conduct the experiment can also constrain students from taking part in experimental activities [7, 15, 16, 17]. Usually, there are extensive time required for both teachers and students to plan and conduct the chemistry experiment as there are many topics need to be covered in the chemistry curriculum [11, 18]. Due to time shortage, teacher tends to put more emphasis on the theories and concepts, sometimes limiting hands-on experience for students to do experiments. In order to acquire substantive scientific thinking and skills, sufficient equipment and conditions are required for these students to carry out experiment to experience meaningful learning [19]. Therefore, to address the issue associated with conventional chemistry experiment, technology plays an important role in providing a more effective and impactful chemistry learning experience.

2.2 Application of Technology in Chemistry Experiment

The integration of technology is important to support chemistry learning and overcome existing problems of conventional chemistry experiments. Technology-based experiments can be just as effective by providing a safe environment where students can conduct the experiments individually and engage more deeply in the learning process [12]. This approach allows students to carry out chemistry experiments safely, at any time and place, without worrying about the risks that might be encountered during real laboratory experiments [20]. Active participation can be ensured through the use of graphics and animations provided by thetechnology, making the learning process more engaging. This approach allows for interactive experiments, such as those conducted in online laboratories.

One example of online laboratories is virtual experiments, which enable students to obtain scientific knowledge in an interactive and safe environment [8, 21]. Virtual experiments have been shown to enhance student achievements and improve their science process skills [11, 22]. According to Haryadi and Pujiastuti [23], interactive learning through virtual experiments can improve the students' science process skills by virtually following the experiment procedures. Virtual experiments also offer practical benefits such as saving time, money, and effort [8]. This is achieved by eliminating the need for expensive laboratory equipment while allowing students to obtain comparable in a shorter timeframe. Thus, the learning process can become more enjoyable and improve student motivation. Previous studies have widely implemented technology that utilises virtual experiments in chemistry education. However, there is a noticeable gap in research on the use of programming in chemistry experiments, even though computational thinking skills are very important and can be developed through programming software. To address those gaps, this study implements a plugged-in chemistry experiment module that utilises programming, aiming to investigate its effects in enhancing both computational thinking and science process skills in students' learning process.

2.3 Programming Teaching and Learning Chemistry Computational Thinking Skills

Computational thinking skills can be defined as a thought process that involves formulation and solving problems in an orderly manner, similar to how a computer processes information and solves problems [29]. Korkmaz, Çakır, and Özden [30] emphasise that skills such as creativity, critical thinking, and logical thinking are important for effective problem-solving with the help of computers. Doleck et al. [31] stated that computational thinking skills is a combination of several aspects including problem-solving, communication skills, algorithmic thinking, critical thinking, and cooperative learning. These computational thinking skills can be considered to be the highest level of problem-solving skills. Not only that, these skills are required to solve daily life problems systematically and effectively [32]. In the education system, enhancing students' ability to formulate and solve problems is the main objective [33]. This objective would work as a foundation and guideline for educators to design learning activities that teach computational thinking to the students. In Malaysia's curriculum, these skills are emphasised in the teaching and learning process to enhance students' computational thinking skills. According to a study by Zakaria and Iksan [34], secondary school students possess a high level of computational thinking skills. This finding is also aligned with research by Korucu [35]. However, this finding is in contrast with a study by Chongo, Osman, and Navan [27], which reported that secondary school students exhibit a moderate level of computational thinking skills.

In the context of chemistry, there are a variety of complex problems that need to be solved. Integrating computational thinking skills into solving chemistry problems will allow educators and students to use logical thinking to solve problems systematically and evaluate problem-solving skills effectively, thus helping them to understand problems more clearly [36, 37]. Throuth this integration, possible solutions can be developed and evaluated to identify the most effective solution to the problems. As the ability to solve chemistry problems is improved, self-confidence and attitude, especially in scientific investigation, can be developed as well. The abstract chemistry concepts, such as those in electrochemistry, can be better understood by implementing computational thinking skills [27]. The visualisation of these abstract concepts by using three levels of representation can improve understanding and prevent misconceptions, which will then enhance students' chemistry achievement [38]. Based on previous studies, decomposition, abstraction, pattern recognition, algorithmic thinking, and evaluation are the most common elements being integrated into computational thinking [39-41]. Therefore, this study will emphasise these elements to enhance students' understanding and application of computational thinking in chemistry.

2.4 Science Process Skills

Another important skill emphasized in the Malaysian curriculum besides computational thinking skills is science process skills. Science process skills are important skills in the 21st century for systematic decision-making or problem-solving, especially for scientists. It can be defined as the ability to apply scientific methods in comprehending, developing, and discovering scientific knowledge [42]. This implies that scientific information acquisition requires students to think scientifically. These skills are also applicable in daily life, helping to solve certain problems like scientists do [43]. According to Maedor [44], students with science process skills can develop higher mental processes, including creative and critical thinking, which can be transferred to other disciplines. As this skill is transferrable, students can apply it in learning chemistry and actively participate in the learning process by independently discovering knowledge [23, 45]. According to Suwaid [46],science process skills can facilitate students to understand various subjects apart from just chemistry, and these skills can also be considered cognitive skills. Research has been conducted by Abungu, Okere & Wachanga [47] investigating the effect of the science process skills teaching approach on chemistry achievement. The research found that this teaching approach significantly impacts students' chemistry achievement, which is consistent with the results reported by [48].

According to previous research, science process skills can be classified into two categories, namely basic science process skills and integrated science process skills, the latter consisting of both basic and complex skills [49, 50]. For basic skills, the common skills listedin previous literature are observing, classifying, inferring, predicting, and communicating [6, 51]. The common skills for integrated science process skills involve controlling variables, interpreting data, defining operationally, hypothesising, and experimenting [55, 57, 58]. For this study, these elements are emphasised excluding interpreting data and defining operationally, as the use of software in the chemistry experiments does not involve collecting data for interpretation.

3 Methodology

This study employed a quasi-experimental research design with pre-test and post-test control groups, adopting a quantitative methodology. The population in this study consisted of Form Four students from secondary schools located in Kulai, Johor. A total of 64 Form Four students were selected through purposive sampling. Among these, two schools comprising of 34 students were assigned to the control group, which implements a conventional chemistry experiment approach. Meanwhile, another school with 30 students was assigned to the experimental group, which implemented a plugged-in chemistry experiment approach using the software named Scratch. The students in both control group and experimental group are equivalent in terms of Chemistry subject achievements in the SPM year 2020, with a 100% passing rate in Chemistry subject are achieved for all three schools. The study administered the Computational Thinking Skills Test and Science Process Skills Test before and after the intervention. The Computational Thinking Skills Test was used to evaluate the students' skills such as abstraction, pattern recognition, decomposition, algorithmic thinking, evaluation. Concurrently, the Science Process Skills Test was used to evaluate the students' skills of observing, classifying, inferring, predicting, communicating, controlling variables, hypothesising, and experimenting. The instruments consisted of 30 multiple-choice questions for each test. These instruments demonstrated a high validity with 95.56% and 98.52% percentage score means for the Science Process Skills Test and Computational Thinking Skills Test, respectively. The reliability coefficients, calculated using the Kuder-Richardson Formula 20 method, were 0.83 for the Science Process Skills Test and 0.74 for the Computational Thinking Skills Test, indicating that these instruments are reliable. This study was conducted in two phases. The first phase is teacher's training, and the second phase involves the implementation of both plugged-in and conventional chemistry experiments, as shown in the experimental procedure in Figure 1. The experiments selected for student investigation involved the chemical properties of Group 1 elements with water, oxygen, and chlorine gas.

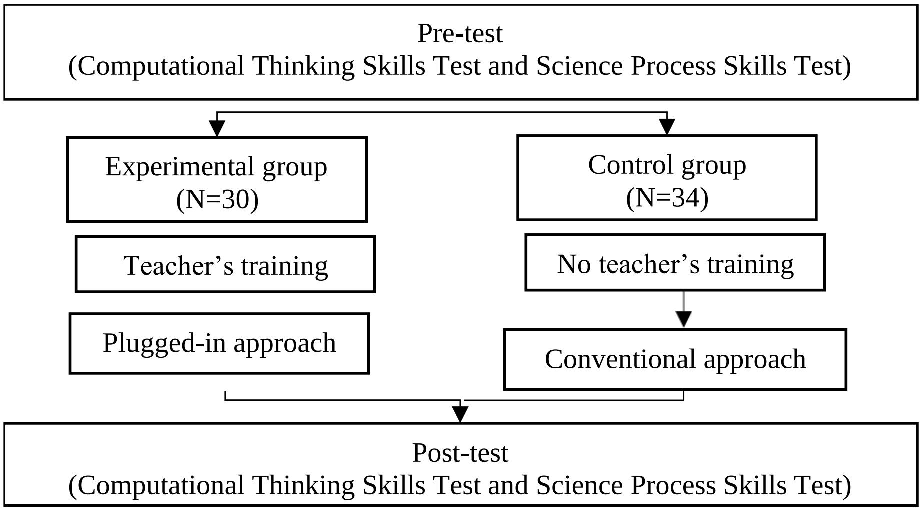

Figure 1. Experimental Procedure

Data analysis was conducted by using Statistical Packages for the Social Science version 26.0 (SPSS). Descriptive statistics which include mean and standard deviation were used to describe the data collected from the instruments. In addition, inferential analyses such as such independent samples t-tests, paired samples t-tests and Pearson Correlation were conducted to achieve the objectives of the study. Independent samples t-tests were used to measure the significance of differences between control group and experimental group for students' science process skills and computational thinking skills. Effect size was also includedat the end of analysis to determine whether the significance difference level is small, medium, or large. Paired samples t-tests were used to measure the mean differences of students' scienceprocess skills and computational thinking skills before and after the implementation of the plugged-in chemistry experiment approach, as well as before and after conventional approach. Lastly, Pearson Correlation was used to measure the relationship between students' computational thinking skills and science process skills.

4 Results

4.1 Analysis of Computational Thinking Skills

Descriptive analysis was conducted to summarise the data collected from the Computational Thinking Skills Test, as shown in Table 1. It was found that the mean score for for the experimental group after implementating the plugged-in chemistry experiment

(M=14.267, SD=3.562) was higher compared to before the implementation (M=10.400, SD=3.420), with a score difference of 3.867. In contrast, the control group showed a mean score after conducting the conventional experiment of (M=10.324, SD=3.111) that is higher than before (M=9.724, SD=3.189), noting a score difference of 0.530. Both groups showed an increase in computational thinking skills following their respective interventions.

Table 1. Mean and standard deviation in Computational Thinking Skills Test for experimentalgroup and control group

Group	Type of test	N	Range	Mean	Std. Deviation
Experimental Group	Pre-test	30	13	10.400	3.420
	Post-test	30	17	14.267	3.562
Control Group	Pre-test	34	12	9.794	3.189
	Post-test	34	11	10.324	3.111

Inferential statistics was carried out to make inference regarding students' skills. An independent sample t-test was used to measure the significance of the difference between experimental group and control group in computational thinking skills. As indicated in Table 2, it was found that the Sig. level for the independent samples t-test was less than α, with p-value of 0.000 ($t=4.728$, $p<0.05$). Therefore, the H_{01} can be rejected, which means that there is a significant difference of the mean scores between experimental group and control groups in computational thinking skills. This result suggests that using Scratch as the plugged-in chemistry experiment was more effective compared to the conventional experiment. The effect size to show the extent of which plugged-in chemistry experiment can affect experimental group's computational thinking skills compared to control group was calculated by using percentage of variance formula. The effect size obtained is 0.265 which shows a large effect size of the plugged-in chemistry experiment on the computational thinking skills.

Table 2. Results for independent samples t-test

Test		t	df	Sig. (2-tailed)
Computational Thinking Skills Test	Equal variances assumed	4.728	62	.000
	Equal variances not assumed	4.688	58.066	.000

Analysis of students' computational thinking skills test scores was conducted using paired samples t-test to measure the significance difference before and after the intervention. Table 3 shows the results for the paired samples t-test of Computational Thinking Skills Test scores. For the experimental group, the Sig. of paired samples t-test is less than α with p-value of 0.000 ($t=-5.491$, $p<0.05$). This indicates that there is a significant difference in computational thinking skills before and after implementation of Scratch. The mean score of computational thinking skills test after Scratch implementation (M=14.267) was higher than before the intervention (M=10.400), with a mean change of 3.867. This result shows that the implementation of the plugged-in chemistry experiment had a significant effect on students' computational thinking skills. The effect size obtained is 0.510, which indicates a large effect size of the plugged-in chemistry experiment on computational thinking skills.

For the control group, the Sig. value for paired samples t-test is greater than α, with p-value of 0.130 ($t=-1.553$, $p<0.05$). This suggests that there is no significant difference in computational thinking skills before and after the implementation of the conventional chemistry experiment. Although the mean score for computational thinking skills after the implementation of conventional chemistry experiment (M=10.324) was higher than before (M=9.794), resulting in a mean change of 0.530, this difference was not statistically significant. This indicates that while conventional chemistry experiments may have some effect on students' computational thinking skills, the effect is not statistically significant.

Table 3. Results for paired samples t-test of Computational Thinking Skills Test scores

Group	Type of Test	N	Mean	t	df	Sig.
Experimental	Pre-test	30	10.400	-5.491	29	.000
	Post-test	30	14.267			
Control	Pre-test	34	9.794	-1.553	33	.130
	Post-test	34	10.324			

4.2 Analysis of Science Process Skills

Descriptive analysis was conducted to summarise the data collected from the Science Process Skills Test, as shown in Table 4. It was found that the mean score for the Science Process Skills Test after the implementation of the plugged-in chemistry experiment (M=20.000, SD=3.353) is higher compared to before the implementation (M=18.167, SD=4.235), with a score difference of 1.833. For the control group, the mean score for Science Process Skills Test after conducting conventional chemistry experiment (M=22.353, SD=2.569) is higher than before conventional experiment implementation (M=18.353, SD=3.093), with a score difference of 4.000. Both groups showed an increase in science process skills following their respective interventions.

Table 4. Mean and standard deviation in Science Process Skills Test for experimental groupand control group

Group	Type of test	N	Range	Mean	Std. Deviation
Experimental Group	Pre-test	30	20	18.167	4.235
	Post-test	30	14	20.000	3.353
Control Group	Pre-test	34	15	18.353	3.093
	Post-test	34	9	22.353	2.569

An independent sample t-test was used to measure the significance of the difference in science process skills between the experimental and control groups. Based on Table 5, the Sig. level for the independent samples t-test is less than α with p-value of 0.002 ($t=-3.172$, $p<0.05$). Therefore, H_{02} can be rejected, which means that there is a significant difference in mean scores between the experimental and control groups. The results shows that the conventional experiment approach was more effective compared to the plugged-in chemistry experiment, as the mean score of control group is higher. The effect size obtained is 0.140 which indicates a large effect size of the conventional chemistry experiment on the science process skills.

Table 5. Results for independent samples t-test

Test		t	df	Sig. (2-tailed)
Science Process Skills Test	Equal variances assumed	-3.172	62	.002
	Equal variances not assumed	-3.120	54.073	.003

Further analysis of the students' science process skills test scores was conducted using a paired samples t-test to measure the significance of the difference before and after the intervention. Table 6 shows the results of the paired samples t-test for the Science Process Skills Test. For the experimental group, it was found that the Sig. value for the paired samples t-test was less than α, with p-value of 0.006 ($t=-2.949$, $p<0.05$). This means that there is a significant difference in science process skills before and after the implementation of Scratch. The mean score after Scratch implementation ($M=20.000$) was higher than before the software intervention ($M=18.167$), resulting that the plugged-in chemistry experiment had a positive effect on students' science process skills. The effect size obtained is 0.231 which shows a large effect size of the plugged-in chemistry experiment on the science process skills.

For the control group, it was found that the Sig. value for paired samples t-was also less than α, with p-value of 0.000 ($t=-7.467$, $p<0.05$). This means that there is a significant difference in science process skills before and after the implementation of the conventional chemistry experiment. The mean score after the intervention ($M=22.353$) was higher than before the implementation ($M=18.353$), with a mean change of 4.000. This result shows that conducting conventional experiment has a significant effect on students' science process skills. The effect size obtained is 0.628 which shows a large effect size of the conventional chemistry experiment on science process skills.

Table 6. Results for paired samples t-test of Science Process Skills Test scores

Group	Type of Test	N	Mean	t	df	Sig.
Experimental	Pre-test	30	18.167	-2.949	29	.006
	Post-test	30	20.000			
Control	Pre-test	34	18.353	-7.467	33	.000
	Post-test	34	22.353			

4.3 Correlation between Computational Thinking Skills and Science Process Skills amongChemistry Students

Analysis of correlation was conducted using Pearson Correlation to analyze whether there is any correlation between students' computational thinking skills and science process skills. Based on Table 7, the significance value is greater than α, with a p-value of 0.797 ($p>0.05$). Therefore, H_{03} is accepted, indicating that there is no correlation between students' computational thinking skills and science process skills. The strength of the correlation coefficient value obtained is $r^2 = 0.001$, which suggests a weak positive correlation which can be concluded as no correlation between students' computational thinking skills and science process skills.

Table 7. Correlation between students' computational thinking skills and science process skills

Group	Type of Test	Computational Thinking Skills Test scores	Science Process Skills Test scores
Experimental	Pearson Correlation	1	.033
	Sig. (2-tailed)		.797
	N	64	64
Control	Pearson Correlation	.033	1
	Sig. (2-tailed)	.797	
	N	64	64

5 Discussion

5.1 Computational Thinking Skills

The study found that students who are using the plugged-in chemistry experiment approach demonstrated higher computational thinking skills than those who are using the conventional chemistry experiment approach. An independent-samples t-test revealed a significant difference between both groups, with the experimental group showing a higher mean score in computational thinking skills, as H_{01} is rejected at a a large effect size. The use of the software Scratch as plugged-in chemistry experiment is proven to be more effective compared to conventional experiment as the mean score of experimental group is higher compared to control group. Therefore, the implementation of Scratch as part of the plugged-in chemistry experiment approach enhances students' computational thinking skills more effectively than the conventional approach.

The benefits of the plugged-in chemistry experiment approach can be seen from the significant positive effect on students' computational thinking skills. Like the study by Millner, Huang and Corbett [52], this study also utilised the virtual programming tool of Scratch, and similarly found that it enhances students' computational thinking skills. Scratch implements key computational thinking elements such as decomposition, pattern recognition, abstraction, algorithmic thinking, and evaluation that helps students to improve their computational skills as well. This approach could also improve their algorithmic thinking skills and apply them whenever necessary. This statement aligns with Korkmaz [53], who found that visual programming tools can develop algorithmic thinking skills, and Quan [54], who found that Scratch can improve algorithmic thinking skills too. In programming, there are steps need to be followed for the computer to carry out the command. To apply to the context of this study, the animation of the reactivity of Group 1 elements was produced by arranging coding blocks, which is one of the features in Scratch, in sequence to design experiment algorithms. Based on the algorithm that has been produced, it will allow the students to create their own visualisations of the experiments, reinforcing their understanding of both the content and the computational methods involved.

Decomposition skills are achieved through the construction of coding blocks, which break down instructions into several manageable parts such as the introduction of the experiment, materials and apparatus involved, procedure and observation of the results. This approach allows students to implement decomposition element, making problem-solving procedures more manageable by breaking down complex problems into simpler, smaller parts. Pattern recognition skills can be recognised as students are able to analyse similarities and differences between experiments with the help of a guided series of commands. Abstraction skills are implemented when students focus on using only the necessary information to create coding blocks instructions. Next, evaluation skills are implemented as students are able to evaluate the most suitable procedure to carry out the experiment. The implementation of technology in chemistry experiment allows a safer experiment process that would otherwise be too dangerous experiment to perform [55]. This approach can foster active participation among students, as they can ngage directly in the experimental procedures by creating animations, allowing them to experience and apply the procedures firsthand.

Computational thinking skills also increased for students that use the conventional experiment approach, even though the mean change in Computational Thinking Skills Test scores for the control group was less than of the experimental group. A paired samples t-test indicated that the conventional chemistry experiment intervention had no significant effect on students' computational thinking skills. However, this approach still influenced students' computational thinking skills, even though not significantly, as carrying out experiments involved problem-solving skills. Since computational thinking skills are also a type of problem-solving skills, this finding aligns with a study by Ratamun and Osman [56], who found that conducting experiments can enhance students' problem-solving skills. In this context, the experiment is viewed as a problem that must be identified and addressed before the actual execution. Students may use certain computational thinking skills, such as algorithmic thinking, as they follow a step-by-step procedure to conduct the experiment.

5.2 Science Process Skills

This study also found that students who used the conventional chemistry experiment approach demonstrated higher science process skills than those who used the plugged-in chemistry experiment approach. An independent-samples t-test indicated that there is a significant difference in the mean scores between both groups in science process skills, as H_{02} is rejected at a large effect size. This result shows that conducting conventional experiment is more effective than using Scratch as a plugged-in chemistry experiment, as the mean score of control group had a higher mean score than the experimental group. Both approaches show significant effects on students' science process skills, with the control group showing a larger significant effect. These findings can be found from the paired samples t-test conducted for both groups, confirming that plugged-in chemistry experiment approach intervention has significant effect on students' science process, at a large effect size. The result shows that implementation of plugged-in chemistry experiment has significant effect on students' science process skills. Similarly, for the control group, the implementation of conventional chemistry experiment approach also enhanced students' science process skills, with the paired samples t-test indicating a significant effect on students' science process skills a large effect size as well. This result shows that conventional experiment approach has significant effect on students' science process skills. The effect size of conventional experiment approach was higher than that of the plugged-in chemistry experiment.

It is proven that science process skills can be more effectively enhanced through conventional chemistry experiment compared to plugged-in chemistry experiment. While both approaches contribute to the develpment of science process skills, the conventional experiment approach shows a more significant effect than plugged-in chemistry experiment. This finding aligns with the research by Ratamun and Osman [56], which demonstrated that physical chemistry experiment can improve students' science process skills more effectively than virtual chemistry experiment. In conventional experiments, students can engage in the basic and integrated science process skills elements such as observing, classifying, inferring, predicting, communicating, controlling variables, hypothesising, and experimenting. For instance, conducting Group 1 elements reactivity greatly involves these set of skills, leading to greater enhancement of science process skills. This is further supported by Jack [57], who found that science process skills can be developed by carrying out practical activities.

The students who perform the conventional experiment will experience the scientific investigation process by themselves from start to finish. Before conducting the experiment, they should be able to identify variables, make inferences, predictions, hypotheses, and draw conclusion, all of which enhance their experimenting skill. For example, students need to predict and make inference which Group 1 element is more reactive with water, oxygen gas and chlorine gas based on element position in the periodic table. Through this experience, they can learn to control variables to manage the substances being manipulated and determine what needs to be measured or observed. In contrast, the plugged-in chemistry experiment approach only allows students to carry out the procedure in coding to produce animations rather than handling the materials and apparatus, as well as observing the result of the experiments directly. While this approach allows them to follow a sequence of steps in coding, it does not provide the same hands-on experience or opportunities for practical skill development. Therefore, with conventional chemistry experiment, student are given the opportunity to carry out hands-on instructional method that can better develop their practical skills, including science process skills [58].

Not only that, direct observation allows students to relate the reactions between Group 1 elements with water and oxygen gas, to their existing cognitive knowledge through visual and auditory senses. Through direct observation, their enhancement of chemistry concepts understanding can be enhanced [59]. The predictions, inferences and hypotheses made from the experiments can be validated and confirmed through these observations, enabling students to analyse results and and link the observation to chemistry theories. This process involves scientific reasoning and allows students to be involved with critical thinking related to both procedural and epistemic knowledge. After the experiments, students should document their observation such as describing in tables to identify the trend of the reactivity. As the experiments are conducted in groups, students tend to discuss with each other throughout the experiment to share ideas, and analyse the results obtained in a collaborative manner. This is opposite with theplugged-in chemistry experiment as there may be less verbal interaction and sharing of ideas among students, as it is primarily focuses on individual computer-based tasks. Consequently, students using this approach tend to focus more on the computers, which may limit opportunities for collaborative idea-sharing and verbal discussions.

The effect of the plugged-in chemistry experiment is not as evident as the conventional experiment approach, primarily because students cannot physically manipulate and handle the real materials and apparatus. However, it still contributes to enhancing students' science process skills. For instance, in Scratch where Group 1 elements reactivity experiment was being conducted virtually, students are able to engage in certain science process skills elements, such as determining variables when creating coding blocks. While the procedure involves arranging coding blocks in a sequence similar to a real experiment, students were not able to physically manipulate the variables. Despite this, the approach helps to develop skills in controlling variables, which is one of the key elements of science process skills. The plugged-in chemistry experiment could also enhances communication skills, particularly non-verbal communication. By expressing experimental ideas through graphics and interactive media in Scratch themselves, the students can articulate their findings creatively. This software allows students to understand, plan, and carry out the experimental procedure step-by-step, thus improving their understanding of experimental proceudres and enhancing their experimental skills. Apart from that, another significant advantage of plugged-in chemistry experiment approach is its ability to repeatedly carry out experiments, which would be in conventional due to time constraints and limited resouces, such as materials and apparatus.

5.3 Correlation between Computational Thinking Skills and Science Process Skills among Chemistry Students

The findings reveal that there is no correlation between computational thinking skills and science process skills among chemistry students, as H_{03} is accepted with a p-value greater than α. The positive correlation coefficient is very weak as it is close to zero, suggesting no meaningful relationship between these skills. Therefore, it can be concluded that an increase in computational thinking skills does not necessarily lead to an increase in science process skills, and vice versa, even though both skills improved after intervention of plugged-in chemistry experiment and conventional experiment approaches. This finding is in contrast with Jack [60], where he stated that science process skills is required for problem-solving practices.

There are several implications that can be found from these findings. The results of the study indicate that the plugged-in chemistry experiment approach is beneficial to the students. It is effective in enhancing students' computational thinking skills, allowing them to approach and solve problems the same way as the computers do. It also effective in enhancing students' science process skills which allow them to carry out scientific investigation with scientific attitudes, much like a scientist would. Realising this, both computational thinking and science process skills should be emphasised in Malaysian's chemistry curriculum specification. Therefore, the plugged-in chemistry experiment approach can serve as a supporting tool in chemistry education, both in teaching and learning, in addition to being enjoyable and engaging for students.

6 Conclusion

In conclusion, the analysis shows that there is a significant difference in both computational thinking skills and science process skills between students that use plugged-in chemistry experiment approach and those that use conventional approach, with the experimental group showing higher mean scores. Additionally, there are also significant differences in computational thinking and science process skills between pre-test and post-test scores for the experimental group. For the control group, there is a significant difference in science process skills between pre-test and post-test scores, but not in computational thinking skills. Correlation analysis shows that there is no correlation between students' computational thinking skills and science process skills.

This study has several limitations. This study involves small sample size due to the limited number of science stream students in of upper secondary schools in Kulai. It is recommended for future studies to utilise a larger sample size to ensure the generalisability and realiability of the results. Additionally, the data collection may have been impacted by time constraint in implementing the plugged-in chemistry experiment, suggesting a need for more time to familiarise students with the use of Scratch software. As teachers act as facilitators for the students to use the software, teacher computer literacy should also be developed to effectively guide the students to use the software. Hence, extended training for teachers on the use of software need to be conducted for future studies.

Furthermore, this study focused solely on chemistry experiments on the topic of Periodic Table, which is reactivity of Group 1 elements with water, oxygen gas and chlorine gas, in alignment with school lesson curriculum of the schools. Thus, future research should explore a variety of different chemistry experiments or experiments from other subjects as well, thus contributing to the enhancement of experimental skills. Evaluating the effectiveness of the plugged-in chemistry module on students' manipulative skills is also suggested, as scientific literacy consists of both science process and manipulative skills.

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