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# Inter-School Synchronous Peer Collaboration in Enhancing the Science Process Skills of Controlling Variables and Formulating Hypothesis Among Low Achieving Year Five Pupils

## *Kolaborasi Rakan Sebaya Antara Sekolah dalam Meningkatkan Kemahiran Proses Sains bagi Mengawal Pembolehubah dan Formulasi Hipotesis dalam Kalangan Murid Tahun Lima yang Berpencapaian Rendah*

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**Abstract**

Science teachers must always try to create innovative learning environments to enhance learning through a variety of teaching-learning approaches. The study focus discussed in this article was to enhance the researcher's low achieving year five pupil's science process skills of controlling variables and formulating hypothesis skills through synchronous inter-school peer collaboration. The researcher prepared the Variable Identification and Formulating Hypothesis Tool (VIFH-tool) which consisted of a hands-on activity to assess the pupils for the two skills. A two-cycle action research was conducted. In the first cycle the researcher taught the two process skills and the pupils carried out the activity in the VIFH-tool. In the second cycle, a peer collaborative session was arranged with a high achieving group of students from another school. The inter-school collaborative session was conducted via a video call using Google Hangouts. In the session, the low achieving pupils presented their results for the VIFH-tool, after which there was discussion and questions and answers between pupils of the two schools about the two science process skills. Then the low achieving pupils individually repeated the activity in the VIFH-tool. The data were analyzed using simple descriptive statistics. The study revealed that most of the low achieving pupils did better at the end of the second cycle.

**Keywords:** science education, science process skills, inter-school collaboration, technology integration, Google Hangouts.

## INTRODUCTION

Modernizing science education in the twenty-first century has become an urgent call among teachers and policy makers. The reason for taking this as an urgent call is because science education is crucial for technology development and an important element for a developing country (Margot & Kettler, 2019; UNESCO BRESCE, 2008). Science education in many nations stands on its own structure regardless of education levels and has become a compulsory subject to be learnt be it in primary or secondary schools. In other words, science education is the bridging medium for one to create and share scientific content in a scientific community.

However, developing a sturdy scientific community, begins from elementary school by exposing the pupils to scientific skills. Learning science should not be merely memorizing facts and sitting for examinations (Harlen, 1999; Karpudewan & Meng, 2017). Indeed, it should be interesting and focus on empowering the learners to gain their competencies (Temiz, 2020). There are studies which tell us that scientific knowledge has been imparted by teachers in science classrooms through developing inquiry-based learning and emphasizing science process skills (Haron, Kamaruddin, Harun, Abas, & Salim, 2017; Margot & Kettler, 2019; Tan, Yangco, & Que, 2020).

Science process skills are divided into two levels namely basic skills and integrated skills (Mei, Kaling, Xinyi, Sing, & Khoon, 2007; Temiz, 2020). Basic skills are observing, measuring and using numbers, communicating, predicting and classifying. Skills such as controlling variables, formulating hypothesis, infering, defining terms operationally, experimenting and interpreting data are categorised as integrated science process skills (Faridah Darus & Rohaida Mohd Saat, 2014; Khairani, Nasution, & Bukit, 2021; Keil, Haney, & Zoffel, 2009). Temiz (2020) discusses that science process skills should not be separated from learning and practice regardless of the learning setting in classrooms. Learners are required to be scientifically knowledgeable especially in basic process skills before they embark on activities involving integrated skills which promote a higher level of understanding (Faridah Darus & Rohaida Mohd Saat, 2014; Karpudewan & Meng, 2017; Temiz, 2020). Besides that, learners are able to comprehend science at a deeper level by acquiring science process skills and prepare themselves in strengthening their content knowledge as they proceed to advanced education levels (Keil, Haney, & Zoffel, 2009; Klofutar, Jerman, & Torkar, 2020; Tan, Yangco, & Que, 2020; Temiz, 2020).

Developing science process skills among school pupils need to be the utmost aim of science education (Ambross, Meiring , & Blignaut, 2014; Mei, Kaling, Xinyi, Sing, & Khoon, 2007; Khairani, Nasution, & Bukit, 2021) as the twenty-first century generation needs scientific literacy (Daniel, 2013; Haron et al, 2017). Khairani, Nasution, and Bukit, (2021) and Tan, Yangco and Que (2020) argued that the pupils must be able to apply science process skills through significant teaching processes in science classrooms. Otherwise, pupils may encounter difficulties in acquiring science process skills if they are not well exposed to these skills in a systematic way and this would push the pupils to practice memorizing concepts instead of understanding in a scientific manner (Harlen, 1999; Faridah Darus & Rohaida Mohd Saat, 2014; Walan & Gericke, 2019).

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## RESEARCH BACKGROUND

Twenty-first century learning styles and teaching approaches are highly discussed among policy makers, teachers and education institutes worldwide. To this end, it is believed that the integration of technology in education unquestionably should not be neglected. Over the years, everyone in the field of education have somehow discussed about the integration of technology in science classroom. It has become a trend in recent times whereby, education officers make professional visits to schools to ensure the teachers integrate technology especially in the science classroom. Having said this, teachers should not neglect practising technology aided teaching approaches as they prepare their pupils with twenty-first century skills that will be needed to flourish in the imminent future (Kaye & Ehren, 2021; Margot & Kettler, 2019; OECD, 2015).

Technology in science education is widely used to enable pupils to engage and interact with peers efficiently and share information to create more innovative individuals (Haron et al, 2017; Margot & Kettler, 2019; Smith, Rudd, & Coghlan, 2008; Tan, Yangco, & Que, 2020). Technology integration and its engagement in science classrooms creates oppurtunities for pupils to improve their learning process from good to better to best (Eady & Lockyer, 2013; Kaye & Ehren, 2021; Margot & Kettler, 2019; Smith, Rudd, & Coghlan, 2008; Tan, Yangco, & Que, 2020). There are many types of technologies integrated in science classrooms namely, computers, smartboards, touch screens, media from websites, social media and web 2.0 communication platforms.

Learning science process skills especially in primary education is crucial for one to acquire scientific knowledge (Turiman, Omar, Daud, & Osman, 2012; Karsli & Alipaşa, 2014; Khairani, Nasution, & Bukit, 2021; Temiz, 2020). This includes acquisition of basic and integrated science process skills. It is also stipulated that before acquiring the integrated skills, a pupil needs to master the basic science process skills. Additionally, consistent access to scientific skills among pupils have widened their critical thinking and problem solving skills (Mei, Kaling, Xinyi, Sing, & Khoon, 2007; Seyhan, 2015; Temiz, 2020).

Pupils' knowledge attainment of science process skills has been vastly correlated with pedagogical approaches practised by teachers in their classrooms (Ambross, Meiring, & Blignaut, 2014; Karpudewan & Meng, 2017; Klofutar, Jerman, & Torkar, 2020; Khairani, Nasution, & Bukit, 2021). This means, to foster a scientific literate community, classroom practises especially the foremost teaching approach must be effective (Haron et al, 2017; Margot & Kettler, 2019). Literature reveals that integration of technology in science classrooms has provided teachers huge opportunities to come up with interactive teaching approaches (Khairani, Nasution, & Bukit, 2021; Tan, Yangco, & Que, 2020). Integration of technology in science classrooms helps teachers to assist their pupils to understand scientific concepts and science process skills besides creating interactive learning environment (Haron et al, 2017; Tan, Yangco, & Que, 2020).

At the present time, with the world shocked by the COVID-19 pandemic, the need to integrate technology in education is even more significant and on the rise. As such, teachers tend to introduce various web-based readily available platforms such as padlet, nearpod, blogging, facebook. However, these platforms are good in textual communication (Mitchell, Friedrich, & Appleget, 2019). Mitchell, Friedrich and Appleget (2019) also asserted that there is a need to engage the users in real-time synchronous peer collaboration especially in a verbal form in order to cultivate professional communication and to harness meaningful learning with the integration of twenty-first century digital tools.

This paper will discuss how two selected integrated science process skills, namely controlling variables and formulating hypothesis were enhanced among the low achieving pupils in the researcher's classroom by real-time synchronous inter-school peer collaboration using the Google Hangouts platform. An action research methodology was used as action research is a very useful method in improving and enhancing weaknesses or solving problems in the classroom.

## STATEMENT OF THE PROBLEM

Comparing with other countries, Malaysian pupils were categorised as minimal achievers in the TIMSS 2019 international assessment. The mean score obtained by Malaysian students in TIMSS 2019 dropped significantly by not achieving the satisfactory standard (Kementerian Pendidikan Malaysia, 2020). Limited proficiency and mastery in science process skills could be a factor of this minimal achievement (Kementerian Pendidikan Malaysia, 2020). Studies tell us that acquiring controlling variables and formulating hypothesis in science education have always been a difficult process among low achieving primary school pupils (Faridah Darus & Rohaida Mohd Saat, 2014; Khairani, Nasution, & Bukit, 2021). These researchers also asserted that many Malaysian pupils did not master the skills. Intstead, they practise rote learning merely to pass examinations.

Although being a science teacher for seventeen years, the researcher still faced difficulties in teaching pupils to acquire the two skills. Experts claim that teacher-centered activities have contributed to this issue (Khairani, Nasution, & Bukit, 2021). The researcher's pupils often memorize the controlling variables and formulating hypothesis skills without really understanding the skills similar to what was claimed by Khairani, Nasution, & Bukit, (2021) and Temiz (2020). Additionally, pupils face difficulties in acquiring the process skills due to lower application of the the scientific inquiry learning approach (Hutapea, Bukit, & Manurung, 2021). As such, most pupils are unable to conduct a proper scientific experiment and weak in preparing a scientific report. In relation to this, Ghavifekr (2020) also mentioned that pupils demonstrate a lower level of scientific communication as well as collaboration.

One of the ways to enhance pupils' science process skills is to impart these skills through an appropriate teaching approach especially with emphasis on twenty-first century learning skills such as collaboration and engagement with peers (Le, Janssen, & Wubbels, 2018; Tan, Yangco, & Que, 2020;

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Walan & Gericke, 2019). However, Le, Janssen and Wubbels (2018) asserted that collaborative learning is not often sufficient in classrooms in present times. In other words, these researchers noted that even though teachers place the pupils in groups for the purpose of collaboration, the pupils are not well guided throughout this learning process. The Ministry of Education has for the past few years put in effort to harness pupils collaboration as a part of the twenty-first century learning process (Kementerian Pendidikan Malaysia, 2013). Nevertheless, although collaborative learning among pupils is commonly adapted in science classrooms, it is important to introduce an effective collaboration process to promote more fruitful and enjoyable learning experiences (Le, Janssen, & Wubbels, 2018).

## RESEARCH OBJECTIVE

This study investigated if inter-school synchronous peer collaboration between a high performing school and a low performing school using the Google Hangouts video call could improve the low achieving year five pupils' integrated science process skills namely controlling variables and formulating hypothesis.

## LITERATURE REVIEW

The literature review will discuss the main concepts involved in the study.

### Peer Collaboration

The term 'Inter-school' is often heard during competitions among schools especially in educational or sports events. Although the term may not be new, the practise it seems is vague in the teaching-learning process (Armstrong, 2015). The idea 'inter-school collaboration' itself is very complex as it involves various ways of collaboration. This practise can be defined as working together to find solutions in a complex situation and improving pupils' learning as well as social interaction skills (Ghavifekr, 2020; Le, Janssen, & Wubbels, 2018). Partnering, networking and engagement are related to inter-school collaboration (Armstrong, 2015; Ghavifekr, 2020). These authors also deliberate that inter-school collaboration has the essence to successfully improve pupils' engagement. Similarly, collective work, cooperative learning, peer teaching, pair learning, joint investigations also refer to peer collaboration (Ghavifekr, 2020; Le, Janssen, & Wubbels, 2018) and indirectly to inter-school collaboration.

Collaborative learning between groups of pupils could promote positive collaboration to enhance their learning through a two way comunication (Le, Janssen, & Wubbels, 2018; Margot & Kettler, 2019) especially pupils from different schools which is closely related to twenty-first century learning (Ghavifekr, 2020). Thus, the Ministry of Education had been working extensively in transforming the education system towards a more dynamic process. Therefore, the ministry has come out with a remarkable blue print which consists of eleven shifts (Kementerian Pendidikan Malaysia, 2013). In the blue print, the seventh shift emphasizes on the application of Information Communication and Technology in education in promoting self-driven learning regardless of pupils' aptitude (Kementerian Pendidikan Malaysia, 2013). Vygotsky (1978) asserted that peer collaboration promotes constructivism which leads to construction of knowledge. Ghavifekr (2020), Le, Janssen and Wubbels (2018) and Margot and Kettler (2019) supported the statement of Vygotsky that peer collaboration enhances knowledge acquisition and this is believed to be an important key in the twenty-first century practices.

According to Vygotsky's theory (1978), the role of a more knowledgable other (MKO) (be it a tecaher or a peer) to enhance the understanding of a pupil is very important. The scaffolding provided by the MKO can move the learner up along the Zone of Proximal Development. This means that the learner will be able to achieve a higher cognitive level of understanding with the help of the MKO compared to if the learners has to understand on his or her own. Thus in the study, peer collaboration was between low achieving and high achieving pupils through the video call feature in Google Hangouts.

**Online Platforms for Collaboration**

In the twenty-first century, online platforms for collaboration have been increasing and improving rapidly and widely being used to enhance collaborative learning (Al-Rahmi, Othman, & Yusuf, 2015; Ansari & Khan, 2020). Basically, online platforms for collaboration let the users to communicate with each other regardless of their geographical location. However, there is no one specific online collaboration platform that is considered to be the most effective since every platform has its own advantages and disadvantages (Ansari & Khan, 2020; Margot & Kettler, 2019). There are various readily available social media collaborative platforms such as Facebook, Youtube, Padlet, Nearpod and Skype. Some of these platforms are available free of charge which enable the users to use with no limitation (Al-Rahmi, Othman, & Yusuf, 2015; Ansari & Khan, 2020). According to Ansari and Khan (2020), Facebook and Youtube were the most visited sites for professional purposes. However, for primary school students, it is not advisable for them to register their Facebook account as they are still under age. Facebook requires the users to be at least thirteen years old in order to obtain an account (Facebook, 2021).

Therefore, for the context of this study, Facebook is not viable as a collaboration platform. Since this study focused on the acquiring of the process skills of controlling variables and formulating hypothesis through 'video call collaboration', textual based web 2.0 sites are deemed not suitable. Therefore, although social media is reported to be very useful for engagement and collaboration (Al-Rahmi, Othman, & Yusuf, 2015), this study utilised Google Hangouts as a collaborative platform after considering its availability to students and teachers. In Malaysia, beginning July 2019, the Ministry of Education provides a range of Google services such as Google Mail (Gmail), Google Drive under the Google Classroom project (Kementerian Pendidikan Malaysia, 2021). These services are provided to every student and teacher nationwide which is considered as an added value for collaboration. According to Google, its platform for collaboration is widely used worldwide and the services are stable most of the time through devices which support a web browser (Google, 2021). Hence, Google

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Hangouts was chosen as it was considered to be the most suitable platform for this study as the researcher wanted synchronous interaction between groups.

**Science Process Skills**

The basic and integrated science process skills cannot be separated from science education as these skills are the key for scientific knowledge acquisition (Hutapea, Bukit, & Manurung, 2021; Khairani, Nasution, & Bukit, 2021; Margot & Kettler, 2019; Tan, Yangco, & Que, 2020). Generally, science process skills are crucial to carry out investigations especially in science classrooms (Daniel, 2013; Khairani, Nasution, & Bukit, 2021). Turiman, Omar, Daud, and Osman, (2012) and Margot and Kettler (2019) put forward that science process skills empowers pupils to make wise decisions upon the investigation. Acquisition of science process skills is a continous process in establishing knowledge which optimizes scienctific studies (Tan, Yangco, & Que, 2020).

Although the claim that science process skills are important in nurturing science learning, researchers often address the perturbing issue in the acquisition of science process skills (Tan, Yangco, & Que, 2020). In other words, Faridah Darus and Rohaida Mohd Saat, (2014) asserted that controlling variables and formulating hypothesis are at a poor level among primary school pupils. Therefore, teachers are expected to teach pupils about controlling variables and formulating hypothesis through scientific investigation and innovative strategies in science classrooms (Karpudewan & Meng, 2017; Klofutar, Jerman, & Torkar, 2020; Jones, 2012; OECD, 2015; Osborne & Hennessy, 2003). Turiman et al (2012) claimed that pupils' acquisition of controlling variables and formulationg hypothesis is essential for pupils in developing some of the twenty-first century skills.

**Action Research in Science Education**

In recent years, action research has become an essential way in finding solutions for issues which arise in the classroom (Hien, 2009; Hine G. S., 2013; Hine & Lavery, 2014; Rose, et al, 2015). In other words, this approach is believed to be a means to improve the teaching quality among teachers who encounter educational issues in classrooms. An action research has been proven to be a feasible and prudent methodology in promoting positive development in science education (Hien, 2009; Hine & Lavery, 2014; Rose, et al, 2015). A very well planned action research has the ability to bridge the gap between teachers and policymakers in designing a meaningful curriculum plan towards achieving twenty-first century skills (Hine & Lavery, 2014).

## METHODOLOGY

This paper is based on a larger postgraduate study which involved a two-cycle action research approach. The samples in this study were year five pupils from two different schools in the Kinta district, Perak. One was a low achieving school where the researcher is based and the other one was a high achieving school. The low achieving school and high performing school were classifed as band three and two respectively by the Ministry of Education, Malaysia. Basically in this study, it was expected that the group of pupils from the high achieving school could lead the collaborative learning process with the low achieving pupils. In other words, the high achieving pupils scaffolded the low achieving pupils in their learning, following Vygotsky's theory (1978). A pilot study was carried out to test out the technology involved which was Google Hangouts.

Three groups (each consisting of 3 pupils) participated from the low achieveing school. One group of 5 students participated from the high achieving school. The researcher had no other choice but to involve only nine low achieving pupils in this study due to several unavoidable circumstances at school level. It must be noted here that the high achieving pupils were involved only as a support group. Hence, there was no data collected nor analysed for the high achieving pupils. Prior to conducting this study, the researcher had obtained approval from the Educational Planning and Research Division (EPRD), Ministry of Education, the Perak State Education Department (JPNP), the parents of the researcher's pupils, the parents of the high performing school pupils and the respective school heads This study employed a descriptive statistics analysis.

Collaborative activities in the first cycle of the study between the three low achieving pupils' groups were labelled as intra-group collaboration. The term inter-school collaboration referred to collaborative activity among groups of pupils from both schools. The inter-school collaboration between the low achieving pupils and the high achieving pupils were carried out in the second cycle of the study. Each group in the low performing school collaborated through the Google Hangouts video call feature with the pupils from the high performing school. The duration for each intra-group session was about an hour and each inter-school session was about two hours. The duration for data collection lasted about one month.

The researcher also prepared an evaluation tool for the year five topic entitled 'electric'. The tool was named as Variable Identification and Formulating Hypothesis tool (VIFH-tool) and was developed based on the year five text book provided by the Ministry. The tool was peer reviewed by three expert science teachers prior to the intra-group sessions.

**The flow of this action research**

The action research approach reported in this paper adapted the Practical Action Research Model which comprises two cycles. During the first cycle, the low achieving pupils carried out a task as given in the VIFH-tool in the intra-group setting. The researcher evaluated the pupils'responses in the VIFH-tool. At the same time, the teacher in the high achieving school conducted the same task with his pupils.

In the second cycle, the researcher introduced both the low and high achieving groups from both schools using the Google Hangouts video call feature. This cycle took place after the intra-group session in which the low achieving pupils had the experiment results handy. Once the Google Hangout connection was established, the low achieving pupils presented their experiment outcomes to the high

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performing pupils through the Google Hangouts video call sessions. The high achieving pupils also had their experiment results handy. Both the groups exchanged their ideas and experiment outcomes verbally. The high achieving pupils explained to the low achieving pupils on how they had controlled the variables, formulated the hypothesis and the results of experiment. During the presentation by the low achieving pupils, the high performing pupils asked questions based on the presentations. While the collaboration was going on, the researcher recorded the session using a smartphone camera for analysis purpose. The figure 1a and 1b below show the summary of the action research cycles.

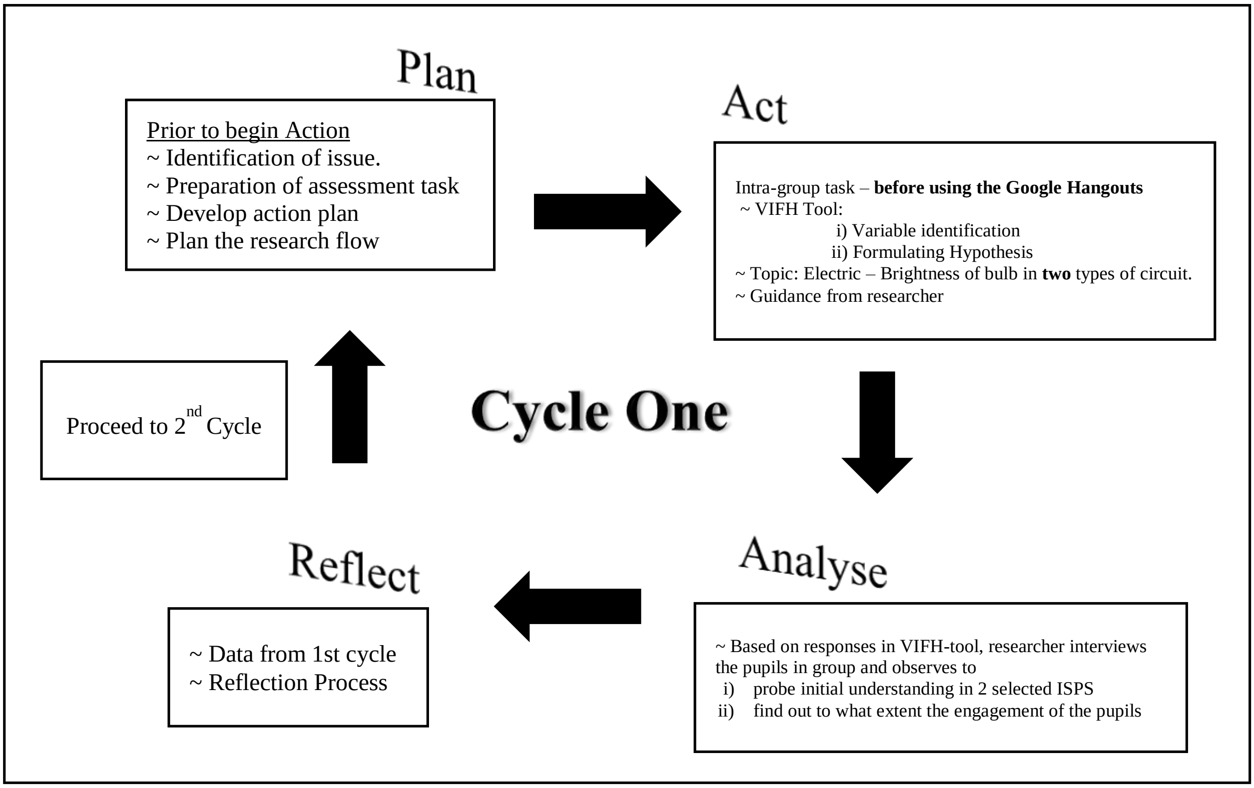


**Figure 1a:** Summary of Cycle One.

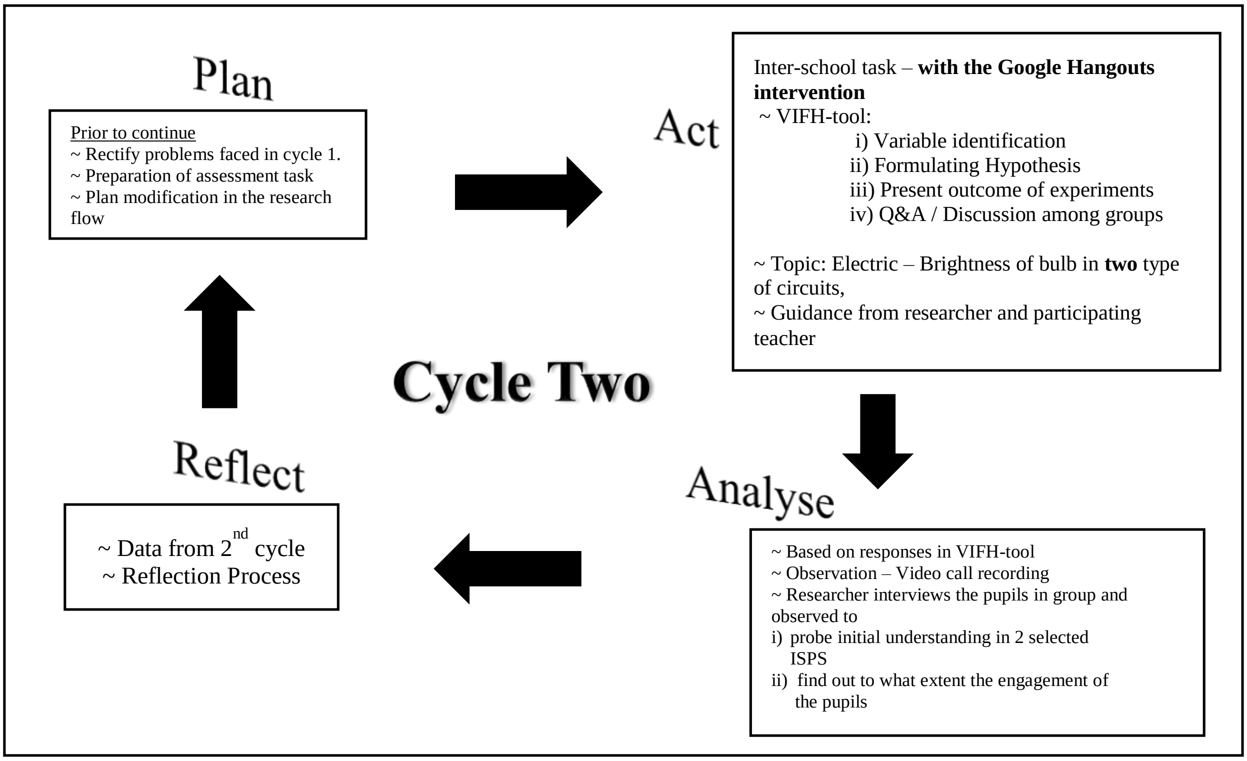


**Figure 1b:** Summary of Cycle Two.

**The data collection techniques**

The researcher checked and analysed his pupils' responses in the VIFH-tool during the firct cycle of research. The responses given by the pupils in the VIFH-tool after the inter-school peer collaboration seesion was also analysed for comparison.

**The data analysis techniques**

The data gathered in this study were analysed using simple descriptive statistics. A score of 0 (zero) was given for wrong responses and 1 (one) for right responses. Frequency of right and wrong scores for the responses were tabulated.

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## FINDINGS AND DISCUSSION

This section will be discussed in two sections.

### Before Inter-School Peer Collaboration

The low achieving pupils were divided into three groups comprising three members in each group. The ability to identify and state controlling variables and formulating hypothesis before the Google Hangouts video call session were at a poor level. All the three groups were not able to formulate hypothesis at the beginning of the VIFH-tool task.

The Table 1a shows excerpts obtained from the VIFH-tool given to all the three groups in the first cycle of the action research, as the pupils conducted intra-group discussions. The low achieving pupils' responses are given in the Table 1a.

**Table 1a:** Excerpts from the VIFH-tool.

| Group | Hypothesis stated |
|---|---|
| Group 1 | *Hipotesis: Semakin banyak mentol digunakan dalam 1 litar semakin berkurang cahaya yang ada pada mentol.*<br>(Hypothesis: The more the bulbs used in 1 circuit, the lesser the brightness of the bulbs) |
| Group 2 | *Hipotesis: Untuk menyiasat hubungan antara kecerahan mentol.*<br>(Hypothesis: To investigate the relationship between brightness of bulbs) |
| Group 3 | *Hipotesis: Semakin banyak mentol, semakin malap kecerahan mentol.*<br>(Hypothesis: The more bulbs, the dimmer the brightness of each bulb) |

The expected responses for the hypothesis was *Mentol yang disambungkan secara selari menyala cerah manakala mentol yang disambungkan secara bersiri menyala malap* (Bulbs in parallel circuit light up bright whereas bulbs in series circuit light up dim).

Based on the excerpts above, the hypothesis statement given by group one and three sounds like a hypothesis but did not reflect the experiment given in the VIFH-tool. Although the method of formulating the hypothesis statement was right, it can be seen that pupils' understanding in formulating hypothesis was not clear. Table 1b shows the scores obtained by the three groups in formulating hypothesis.

**Table 1b:** Scores for Formulating Hypothesis.

| Item | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| Formulating Hypothesis | 0 | 0 | 0 |

*0 = Incorrect response*
*1 = Correct response*

Similarly, the pupils were not able to identify the controlling variables although the experiment was carried out by the group. Table 2a shows the responses given by the groups for the constant variable. Table 2b reflects the scores obtained by each group for constant variable.

**Table 2a:** Responses Given by the Groups for the Constant Variable.

| Group | Constant Variable Stated |
|---|---|
| Group 1 | *Bilangan alat yang digunakan*<br>(Number of objects used) |
| Group 2 | *Komponen mentol*<br>(Bulb component) |
| Group 3 | *Jenis bateri / sel kering*<br>(Type of battery / dry cell) |

**Table 2b:** Scores Obtained by Each Group for the Constant Variable.

| Item | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| Constant Variable | 0 | 0 | 1 |

*0 = Incorrect response*
*1 = Correct response*

As for the manipulated variable and responding variable, Table 3a shows the responses given by the three groups. The correct responses were *jenis litar* and *kecerahan mentol* respectively. Faridah Darus and Rohaida Mohd Saat, (2014) and Temiz (2020) highlighted that manipulated and responding variables are important to formulate hypothesis.

**Table 3a:** Manipulated and Responding Variables.

| Group | Manipulated and Responding Variable Stated |
|---|---|
| Group 1 | *Pemboleh ubah dimanipulasi: Kecerahan mentol*<br>(Manipulated variable: Brightness of bulb)<br>*Pemboleh ubah bergerakbalas: Jenis litar*<br>(Responding variable: Type of circuit) |
| Group 2 | *Pemboleh ubah dimanipulasi: Kecerahan mentol*<br>(Manipulated variable: Brightness of bulb)<br>*Pemboleh ubah bergerakbalas: Bergerak balas mentol*<br>(Responding variable: Responding bulb) |
| Group 3 | *Pemboleh ubah dimanipulasi: Kecerahan mentol*<br>(Manipulated variable: Brightness of bulb)<br>*Pemboleh ubah bergerakbalas: Litar*<br>(Responding variable: Circuit) |

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The scores obtained by each group in the manipulated variable and responding variable are presented in the table 3b.

**Table 3b:** Scores Obtained by Each Group for the Manipulated Variable and Responding Variable.

| Item | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| Manipulated Variable | 0 | 0 | 0 |
| Responding Variable | 0 | 0 | 0 |

*0 = Incorrect response*
*1 = Correct response*

Based on the data presented, the ability to identify controlling variables and formulating hypothesis among the low achieving pupils were at a very poor level. This is similar to a study carried out by Faridah Darus and Rohaida Mohd Saat (2014) and Walan and Gericke (2019) where the pupils face difficulties in controlling variables and formulating hypothesis.

**After Inter-School Peer Collaboration**

After the video call session through Google Hangouts with the high achieving pupils, the VIFH-tool was administered again to each pupil (this time individually) in their groups where Group 1 consisted of pupils 1, 2 and 3; while Group 2 consisted of pupils 4, 5 and 6 and the third group consisted of pupils 7, 8 and 9. The responses given by the pupils were different compared to the responses given in the first cycle VIFH-tool responses, as five of them were able to formulate hypothesis well. This is evident that the inter-school synchronous peer collaboration between the high achieving and the low achieving pupils appeared to have enhanced five of the low achieving pupils identification of the controlling variables and to formulate hypotheses. However, four pupils were not able to formulate hypothesis as discussed in the inter-school collaboration. Table 4 shows the scores obtained by the low achieving pupils for formulating hypothesis.

**Table 4:** Scores for Formulating Hypothesis.

| Item | Group 1 | | | Group 2 | | | Group 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pupil 1 | Pupil 2 | Pupil 3 | Pupil 4 | Pupil 5 | Pupil 6 | Pupil 7 | Pupil 8 | Pupil 9 |
| Formulating Hypothesis | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| Stating reason for Formulating Hypothesis | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |

0 = Incorrect response
1 = Correct response

After the inter-school collaboration, all the nine pupils stated the constant variables correctly. They also correctly stated the reason for stating the constant variable. Comparing with scores from the first cylce, the pupils were able to identify and state the constant variable with the relevant parameters for example type of battery (*jenis bateri*). Table 5a shows the example of two pupils' responses for the constant variable and their reasons while Table 5b shows the scores obtained by all the nine the pupils for the item of constant variable.

**Table 5a:** Example of Responses by Two Pupils for the Constant Variable.

| **Pupil** | **Constant Variable and Reason** |
|---|---|
| Pupil 1 | *Pemboleh ubah dimalarkan: Jenis bateri*<br>(Constant variable: Type of battery)<br>*Mengapakah anda memilih pembolehubah tersebut?*<br>(Why do you choose this variable?)<br>*Kerana bateri yang dibekalkan dalam ujikaji ini sama jenis*<br>(Because the batteries provided in this investigation were same type) |
| Pupil 2 | *Pemboleh ubah dimalarkan: Kuantiti mentol*<br>(Constant variable: Quantity of bulb)<br>*Mengapakah anda memilih pembolehubah tersebut?*<br>(Why do you choose this variable?)<br>*Arahan dalam ujikaji menyatakan mentol ialah komponen yang sama*<br>(The instruction in this investigation mentioned that bulb was same component) |

**Table 5b:** Scores for Constant Variable Obtained by All the Nine Pupils.

| **Item** | **Group 1** | | | **Group 2** | | | **Group 3** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pupil 1 | Pupil 2 | Pupil 3 | Pupil 4 | Pupil 5 | Pupil 6 | Pupil 7 | Pupil 8 | Pupil 9 |
| Constant Variable | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Stating reason for Constant Variable | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

0 = Incorrect response
1 = Correct response

As for the manipulated variable, eight pupils identified it correctly. They were also able to state reasons for their selection of manipulated variable. The pupils also stated the variables with correct parameters. Table 6a shows examples of two pupils' responses for the manipulated variable and their reasons while Table 6b shows the scores obtained for the manipulated variable.

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**Table 6a:** Example of Responses by Two Pupils for the Manipulated Variable and Their Reason.

| Pupil | Manipulated Variable and Reason |
|---|---|
| Pupil 3 | *Pemboleh ubah dimanipulasi: Jenis litar*<br>(Manipulated variable: Type of circuit)<br>*Mengapakah anda memilih pembolehubah tersebut?*<br>(Why do you choose this variable?)<br>*Kerana jenis litar yang digunakan adalah berbeza iaitu litar bersiri dan litar selari*<br>(Because the type of circuit used were different which is series circuit and parallel circuit) |
| Pupil 4 | *Pemboleh ubah dimanipulasi: Jenis litar*<br>(Manipulated variable: Type of circuit)<br>*Mengapakah anda memilih pembolehubah tersebut?*<br>(Why do you choose this variable?)<br>*Kerana arahan dalam ujikaji meminta saya untuk memasang dua litar*<br>(Because the instruction in this investigation requires me to form two circuits) |

**Table 6b:** Scores for Manipulated Variable Obtained by All the Nine Pupils

| Item | Group 1 | | | Group 2 | | | | Group 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | Pupil 1 | Pupil 2 | Pupil 3 | Pupil 4 | Pupil 5 | Pupil 6 | Pupil 7 | Pupil 8 | Pupil 9 |
| Manipulated Variable | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| Stating reason for Manipulated Variable | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |

0 = Incorrect response
1 = Correct response

The low achieving pupils have shown improvement in stating the responding variable after the inter-school synchronous peer collaborative session via Google Hangout video call. Similar to the scores for the manipulated variable, only one pupil did not get through with a right response. The remaining eight pupils have stated the responding variable correctly. They were also able to state reasons for the selection of their responses. Likewise, for the other two variables, the pupils did mention the right parameters for the responding variable. This finding is slightly contradicting to what claimed by Temiz (2020) in his study that nearly one fifth of the samples failed to identify manipulated variable in the first part of his study which eventually affected the formulation of hypothesis statement. Table 7a shows examples of two pupils' responses for the responding variable and their reasons while Table 7b shows the scores obtained for the responding variable.

**Table 7a:** Example of Responses by Two Pupils for The Responding Variable and Their Reason

| Pupil | Responding Variable and Reason |
|---|---|
| Pupil 7 | *Pemboleh ubah bergerakbalas: Kecerahan mentol*<br>(Responding variable: Brightness of bulb)<br>*Mengapakah anda memilih pembolehubah tersebut?*<br>(Why do you choose this variable?)<br>*Kerana keputusan hendak melihat kecerahan mentol*<br>(Because the result was to observe brightness of bulb) |
| Pupil 8 | *Pemboleh ubah bergerakbalas: Kecerahan mentol*<br>(Responding variable: Brightness of bulb)<br>*Mengapakah anda memilih pembolehubah tersebut?*<br>(Why do you choose this variable?)<br>*Kerana tujuan penyiasatan ini adalah untuk menguji kecerahan mentol*<br>(Because the aim of the investigation was to investigate the brightness of the bulb) |

**Table 7b:** Scores for Responding Variable Obtained by All the Nine Pupils

| Item | Group 1 | | | Group 2 | | | | Group 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | Pupil 1 | Pupil 2 | Pupil 3 | Pupil 4 | Pupil 5 | Pupil 6 | Pupil 7 | Pupil 8 | Pupil 9 |
| Responding Variable | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Stating reason for Responding Variable | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

0 = Incorrect response
1 = Correct response

Based on the pupils' responses in the VIFH-tool, after the inter-school synchronous peer collaborative session, it can be seen that there is enhancement in the pupils' ability in controlling variables and formulating hypothesis. The Google Hangouts video call feature helped in connecting the two schools to bring about a different learning experience. Jones (2012), Osborne and Hennessy (2003) and Margot and Kettler (2019) emphasized that pupils' understandings of scientific concepts and principles could be boosted through technological applications in science classrooms besides soaring their enjoyment of learning science. The presence of technology in a classroom gets pupils excited to learn (Tan, Yangco, & Que, 2020; Wang, 2014), which happened in the present study.

Nevertheless, a few of the pupils in this study showed slower improvement in the selected integrated science process skills. For these pupils, the researcher had to conduct another round of teaching activity with other technological tools such as animations and pre-recorded videos to ensure that they also attained the necessary knowledge.

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## CONCLUSION

Science process skills are crucial for development of pupils' scientific knowledge (Tan, Yangco, & Que, 2020; Temiz, 2020). For a scientific community to be established and to grow, science education must be interesting (Daniel, 2013) and should always attract pupils towards active learning (Faridah Darus & Rohaida Mohd Saat, 2014; Temiz, 2020). To create an interesting learning environment in science classrooms, teachers need to innovate using various technologies (Karpudewan & Meng, 2017; Klofutar, Jerman, & Torkar, 2020; Temiz, 2020; OECD, 2015). The innovation practiced in this study by introducing Google Hangouts in the inter-school synchronous peer collaboration is one example of a twenty-first century teaching approach which can benefit science teachers and pupils.

The findings revealed that the low achieving pupils in this study having been scaffolded by the high achieving pupils, managed to improve their skills of controlling variables and formulating hypothesis. Such beyond classroom collaboration has great potential in pupils' science learning. This is just one way to improve the pupils' science learning besides encouraging the pupils to collaborate beyond classroom. There are so many other technological tools for education to encourage collaboration. Perhaps the next step of beyond classroom collaboration can be with pupils in other nations, which perhaps can further enhance the learning of science in our classrooms.

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