SciEd

SEAQIS Journal of Science Education

vol. 2 / no. 1 / June 2022
E-ISSN 2964-7533
P-ISSN 2987-8101
DOI prefix: 10.58249 by Crossref

www.journal.qitepinscience.org

SciEd

SEAQIS Journal of Science Education

Director's Message

Welcome to the 2nd volume of SEAQIS Journal of Science Education (SciEd). This is the first issue of the 2nd volume and still devoted to the science education field from theoretical aspects to practical studies.

This journal is the authoritative voice in science education field, covering science curriculum, instruction, learning, policy, and science teachers' preparation to advance our knowledge in science education theory and practice. The journal's focus is on the teaching and learning of science in a school setting ranging from primary education to secondary education.

This journal can also be the platform for teachers and education personnel to share their ideas on the current issues in science education world. We know that nowadays, science education is fundamental for growing our scientific literacy skills and nurturing the next generation of scientists. In this fast-paced world where technological and scientific advancements are growing rapidly, scientific literacy is crucial to help us in understanding the knowledge we receive.

We believe that all the papers published in this journal will significantly influence science education world, and we thank all of the authors who have contributed in this volume.

Dr Indrawati
Director

From the Editor-in-Chief

Welcome to the first issue of the 2nd volume of SciEd, SEAQIS Journal of Science Education. This journal is aimed to cater the needs of science teachers and education personnel towards the current issues and ideas related to this field.

In this opportunity, we would like to extend our gratitude to the authors, the Editorial Board, the designer, the Publishing Office staffs, and those who have contributed in the journal's publication. We specially thank for our journals' readers, because we will not be able to exist without you. We are also inviting you to collaborate with us by submitting your manuscripts for the upcoming editions. We believe that our collaboration could produce insightful knowledge for the readers. Happy reading!

Dr Elly Herliani
Editor-in-Chief

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P-ISSN 2987-8101

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Volume 2 | No 1 | June 2022
E-ISSN 2964-7533
P-ISSN 2987-8101

SEAQIS Journal of Science Education (SciEd), The Southeast Asian Journal of Science Education, is a scientific publication of SEAMEO QITEP in Science published twice a year. It contains scientific research articles in science education and a review article. A guide for the author can be found on the website.

SciEd Editorial Office
SEAMEO QITEP in Science, Jl. Diponegoro No. 12, Bandung, West Java 40115, Indonesia
E-mail: seaqis.journal@seameo.id | Home page: https://journal.qitepinscience.org

Cover:
Art of Photography about science learning daily at home

2022
SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 2, No: 1, PP: 1-8
www.journal.qitepinscience.org
Research Paper
Open Access

The Impact of Mind Mapping in Modelling Instruction to Improve Students' Conceptual Understanding

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Abstract

Mastering the basic concepts of life organisation systems is one of the main goals of learning science at the junior high school level. This study has the main objective to find out how the influence of mind mapping in learning modelling instruction systems improves students' conceptual understanding of life organisation topic. This research is experimental research with a post-test-only control group design. The population of this research is the seventh-grade students of SMP Al Munawwariyyah Malang. The Sample consisted of 30 control class students and 34 experimental class students which were selected using a purposive sampling technique. The research was carried out in class VII SMP Al Munawwariyyah, Malang in the academic year 2021/2022. Results of the t-test showed that there was a significant difference between the experimental and control classes with a significance of <0.05 (2-tailed). The average score of conceptual understanding of the experimental class students was 66.8> 58.0 higher than the average concept understanding of the control class. Based on the calculation of the effect size obtained a value of 0.64 (enough category) which indicates that mind mapping has a positive enough effect on students' understanding of concepts in modelling instruction learning. Further research is needed to explore the effectiveness of mind mapping in more detail on different topics or subjects.

Keywords: Concept understanding; Life organization system; Mind mapping; Modelling instruction.

Introduction

Natural science is a branch of science that focuses on studying living and inanimate objects and their interrelated interactions both on a micro and macro scale. According to Astuti (2020), natural science is more of a science that studies nature systematically, both facts, concepts, principles, and the process of discovery. The breadth of science material has an impact on its coverage. Scientific branches make science a compact and interesting knowledge. Natural science is a science that is based on real truth which formed by scientific experiments. Both laws, theories, and natural science hypotheses are always based on appropriate scientific research. As such a structured science, natural science learning must also adapt to the characteristics of science itself.

The science curriculum itself is designed to equip students with scientific character. These scientific character values are provided to students through a series of scientific methods to form critical thinking skills (Sulaeman, 2018). The purpose of learning science at the junior high school level is to master the basic concepts of science through a series of scientific activities that foster scientific character. One of the science materials at the junior high school level is the life organisation system. In this material, students are taught the level of organisation of life from the cell level to the organism. Of course, students must be taught through a series of steps similar to how science scientists study it.

Various learning models can be chosen to bridge students in mastering science concepts through a series of scientific activities. Some of them are discovery-based learning such as discovery learning (Mustofa, 2021), modelling such as modelling instruction (Mustofa & Asmichatin, 2018), and cooperative-type models such as STAD (Mustofa, 2016). From many learning models, one that is suitable for learning material that has a hierarchy from abstract to the concrete is modelling instruction. This learning model can also accommodate the way of learning like a scientist so that the scientific character of students can also be built.

The modelling instruction learning model is a learning model that focuses on facilitating students to find fundamental concepts. Through a series of activities, students are taught to find and analyse various structural phenomena of a life organisation hierarchy. Modelling instruction has two stages of learning, namely the development model and the deployment model (Jackson, Dukerich, & Hestenes, 2008). Modelling instruction emphasises the development of an inquiry model of phenomena with various representations to increase student participation to achieve a complete understanding of the concept (Taqwa, Utomo, & Yasrina, 2021; Mustofa & Asmichatin, 2018). In the first stage, namely model development, students are taught to observe phenomena, make models related to the concepts of phenomena studied, as well as test and validate the models that have been built. Furthermore, at the model deployment stage, students are invited to solve relevant problems by utilising a valid model to solve problems.

On the other hand, there are many collaborative learning models with various relevant method, and one of them is mind mapping to strengthen the achievement of students' experiences in constructing their understanding of the need for additional media. Mind mapping is a series of meaningful interconnected concepts which constructed by student based on what they learn to make them understand. Mind mapping facilitates students to construct their knowledge in meaningful way to associate ideas, connect concepts, and think creatively that can make their brains' function will be more optimal (Mustofa, Parno, & Masjkur, 2015).

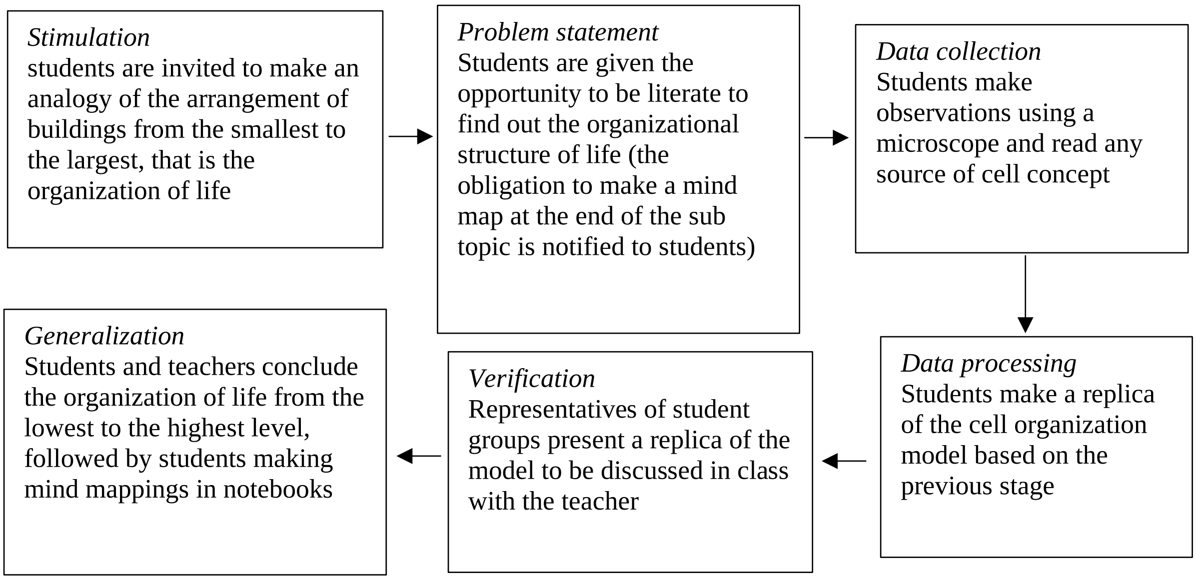
This study focuses on knowing the effect of using mind mapping in learning modelling instruction. Referring to the advantages of mind mapping and modelling instruction, this research focuses on verifying how well the collaboration of mind mapping in modelling instruction on topic of organisation life. Therefore, this study has two problem formulations: (1) How is the effect of mind mapping in learning modelling instruction on the topic of life organisation systems? (2) How is the comparison of the mastery concept of life organisation system between students who are taught by modelling instruction assisted by mind mapping with modelling instruction only?

Methods: Research Design

This experimental study used a post-test-only control group design (Rukminingsih, Adnan, & Latief, 2020). The population of this research was the seventh-grade students of SMP Al-Munawwariyyah, Malang. Sample selection was using a purposive sampling technique. The samples were students of class VII-D as the control class and VII-J as the experimental class. The experimental class is taught with an instruction learning model with the obligation to make mind mapping, while the control class is taught with the instruction learning model. The control class consisted of 30 students, and the experimental class consisted of 34 students. The research was conducted in the academic year 2021/2022.

The learning model given to both classes is the same, namely the instruction modelling model. The learning stages of modelling instruction are presented in Figure 1. It appeared that the learning stages included six stages. The difference between the experimental and control classes was only in the obligation to make a mind map at the end of each sub-topic material which was divided into sub-topics: (1) cells; (2) tissue; (3) organs, organ systems, and organisms.

Figure 1. Stages of learning Modelling instruction topic of life organization system



The study consisted of three stages, namely the stage of making instruments, collecting data, and analysing data and conclusions. The instrument-making stage was carried out to ensure that the treatment and measurement instruments were valid. The treatment instrument consisted of a lesson plan (RPP) and student worksheets (LKPD). The instrument was intended to measure students' understanding of organisation of living in the form of multiple-choice test. The concept understanding test consisted of 20 questions. After all the items were made, they were empirically validated on 62 students who had studied the material for living organism systems. A detailed description of the indicators, the results of the calculation of differentiating power, the level of difficulty, and the correlation coefficient are presented in Table 1. Then, the reliability coefficient value was calculated using SPSS and the Cronbach alpha value was 0.575 (high enough). This value indicated that the instrument for measuring students' conceptual understanding could be used to measure with certainty and steadily with a fairly reliable level (Khumaeni, 2012).

After the instrument was ready, learning research was carried out in both classes according to the RPP and LKPD made. After learning was complete, a final assessment of the chapter was carried out using measurement instruments. After the data for the two classes were obtained, data analysis was carried out. The first data analysis was used to answer the first problem, namely by using descriptive statistical analysis, the different test using the Mann Whitney non-parametric test to determine the difference between the two classes, and the effect size to test how much influence mind mapping had in learning modelling instruction. The second data analysis was used to answer the second problem formulation, namely by comparison analysis of answers using percentage data for both experimental and control class students on several essential concepts in the material organisation of living systems.

Table 1. Characteristic of test of conceptual understanding of organization of living systems

Number	Question Item Indicator	Power of Difference	Level of Difficulty	Correlation coefficient
1	Given several choices regarding the level of organization of life, students can choose the meaning of the given organizational level	0,12	0,97	0,41
2	Given a description of cell types, students can choose the division of cell types based on the presence of a nuclear membrane	0,41	0,62	0,43
3	Given several types of living things, students can determine the types of living things that have prokaryotic cells	0,35	0,60	0,40
4	Given two pictures of animal and plant cells, students can distinguish between each part	0,06	0,90	0,21
5	Given two pictures of animal and plant cells, students can analyse one of the functions of the cell parts	0,53	0,82	0,56
6	Given two pictures of animal and plant cells, students determine the part of the cell that can carry out the function of photosynthesis	0,53	0,52	0,41
7	Given two pictures of animal and plant cells, students analyse the function of one of the cell components	0,18	0,92	0,33
8	Given a description of vacuoles, students can distinguish the size of vacuoles in animal and plant cells	0,41	0,70	0,40
9	Given a description of the tissue, students can determine the tissue in plants that is used as a place for photosynthesis	0,59	0,30	0,48
10	Given a description of spongy tissue, students can analyse the two transport bundles present	0,24	0,73	0,23
11	Given a description of the skeleton as a means of locomotion, students can determine which tissue is responsible for movement	0,41	0,73	0,48
12	Given a description of smooth muscle, students can identify the organ composed of smooth muscle	0,35	0,42	0,27
13	Given several levels of organization of life, students can determine the appropriate level for a set of tissues	0,41	0,48	0,29
14	Given one of the organ functions, students can determine the organ that carries out that function	0,12	0,30	0,06
15	Given a description of the characteristics of the organ and its function, students can determine the organ in question	0,29	0,70	0,28
16	Given a description of organ systems, students can describe one of the organ systems	0,29	0,78	0,33
17	Given several organs that make up organ systems, students can group them into the appropriate organ systems	0,35	0,85	0,28
18	Given several organs that make up the organ system, students can eliminate organs that do not match the organ system in question	0,06	0,12	0,03
19	Given several organs in plants, students can group organ systems in plants	0,12	0,93	0,20
20	Given several levels of organization of life, students can define a description of the level of the organism	0,71	0,68	0,57

Result and Discussion

Comparison of Students' Conceptual Understanding on Materials of Living Organisational Systems

Descriptions of students' conceptual understanding could be obtained through descriptive statistical analysis. Descriptive statistical analysis was presented in Table 2. It appears that the average value of the experimental class = 67.8 > 58.0 = the average value of the control class. Based on the skewness value data, it appeared that the experimental class had values outside the range of -1 to +1 so that the data was not normal, so parametric tests could not be carried out and must be continued with non-parametric tests. Based on the results of the Mann-Whitney non-parametric difference test, a 2-tailed significance value of 0.012 was obtained, which was smaller than 0.05. These results indicated that there was a significant difference between the experimental class and the control class.

Table 2. Descriptive Statistical Analysis

Aspects	Experimental Class	Control Class
N	34	30
Min	20,0	20,0
Max	85,0	90,0
Average	67,8	58,0
Sd	14,15	16,84
Skewness	-1,30	-0,38

Based on the calculated effect size value, it was obtained 0.64 (fair category). This showed that learning modelling instruction with mind mapping had enough influence on students' conceptual understanding compared to learning modelling instruction alone. This was in line with research conducted by Nurazizah, Sudarto, and Yunus (2017) that mind mapping had an influence on improving students' creative thinking skills. Through the mind mapping strategy, students' mastery of concepts in the material being studied would be deeper, considering that mind mapping functioned as brainstorming, problem-solving, reminders, information, and consolidation media from various sources (Mustofa, Parno, & Masjkur, 2015). In addition to increase mastery of concepts, the mind mapping method also increased student creativity which led to complete and meaningful mastery of the material (Latifah, Hidayat, Mulyani, Fatimah, & Sholihat, 2020).

Judging from the learning carried out in each class, the actual stages and activities carried out were the same. However, technically, the obligation to create a mind mapping had an impact on the early stages of modelling instruction. At the model development stage, it appeared that the experimental class that was required to make mind mapping was more enthusiastic in developing the model they were learning. One of mind mapping made by student was presented at Figure 1. This could be seen from the results of the development of animal and plant cell models from both classes in Figure 2. It appeared that Figure 2a was one of the experimental class student's cell model works, while Figure 2b was one of the control class student's cell model works. Experimental class students who were required to make mind mapping were more enthusiastic in developing models that were easy to understand with higher creativity than the models developed by control class students. This was in line with research conducted by Afdholiyah, Anjarini, and Purwoko (2021) that the mind mapping method increased students' creativity in learning.

As for the deployment model stage-namely utilising the model that had been developed to solve the problem-it was also influenced by the results of the model. The difference was significant because the model developed by the control class students tended to be less attractive to be presented in front of the class compared to the model developed by the experimental class students. While doing a comparative analysis between animal cells and plant cells, the experimental class students were able to use the model well to describe it, while the control class students tended to open the pictures in the book to solve them.

Figure 1. Mind Mapping of Cell and Tissue

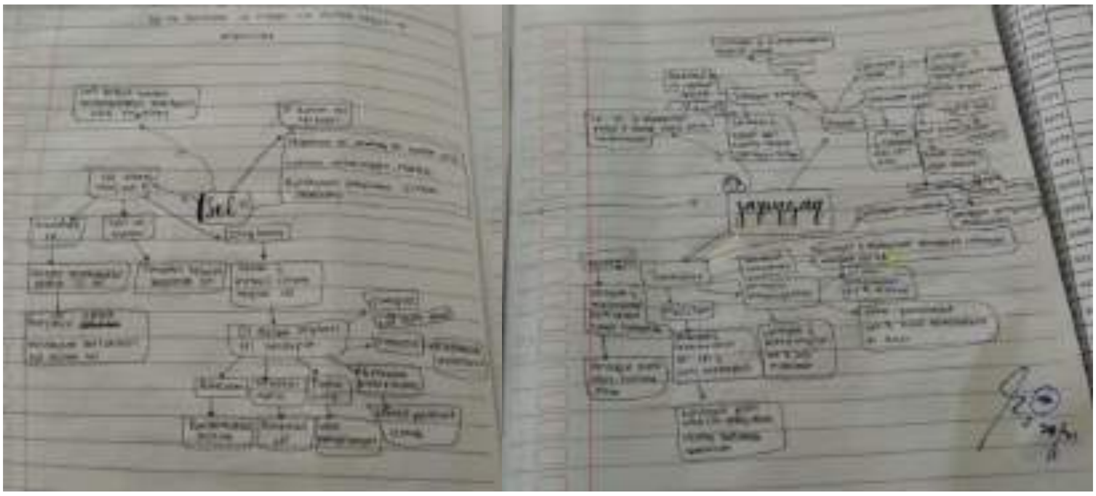


Figure 1. Cell model developed at the model development stage

(a) (b)

Comparison of Students' Understanding of Various Essential Concepts

The essential concepts in the material organisation of living systems were divided into three: (1) cells; (2) tissues; and (3) organs, organ systems, and organisms. The essential concept was an organisational sequence of living systems that must be mastered by students. The comparison between students' understanding was presented in Table 3.

Table 3. Comparison of Understanding of Essential Concepts

Essential Concepts	Experimental Class	Control Class
Cell	66,3%	78,7%
Tissue	49,2%	55,9%
Organs, Organ Systems, and Organisms	54,2%	62,9%

The concept of cells was obtained from items number 1-8, the concept of tissue was obtained from items numbered 9-12, and the concepts of organs, organ systems, and organisms were obtained from items numbered 13-20. Based on the advanced analysis of each concept in Table 3, it appeared that in the cell material, experimental class students had better mastery of concepts (78.7%) than the control class which was 66.3%. Meanwhile, in the tissue concept, the experimental class students mastered 55.9% better than the control class, which was 49.2%. In the concept of organs, organ systems, and organisms, the experimental class students mastered 62.9% better than the control class, which was 54.2%. It was suspected that the maximum mastery of concepts in the essential material of cells, tissues, organs, organ systems, and organisms had not yet been achieved because students' memory of the concept discovery process had not been maximized or students may also experience misconceptions in the material of cells and tissues of animals and plants, as in line with the research from Sartika, Susilo, and Sulisetijono (2020).

Conclusion

Based on the results of the discussion analysis, it is found that students' understanding of concepts taught by modelling instruction with mind mapping is better than only taught by modelling instruction. The average number of students who are taught by modelling instruction with integrated mind mapping is about 67.8, which is greater than the average score of 58.0 who are taught only by modelling instruction. The results of the calculation of the effect size show that the influence of mind mapping on learning modelling instruction is in the adequate category.

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2022
SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 2, No: 1, PP: 9-18
www.journal.qitepinscience.org
Research Paper
Open Access

Effectiveness of Whole Brain Teaching Style in Enhancing the Academic Performance of Grade 11 Students in General Chemistry I

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Abstract

This study aims to determine the effectiveness of Whole Brain Teaching (WBT) Style in enhancing the academic performance of students of Don Ramon E. Costales Memorial National High School, Villasis, Pangasinan, Philippines in General Chemistry I. The study reveals that: (1) WBT Style is an effective instructional strategy which enhanced the academic performance of students in General Chemistry I; (2) there was a significant difference between the performance of students taught using WBT Style and students taught using the traditional method in terms of their posttest mean scores; (3) there was a significant difference in the mean scores change of the students after the WBT style was implemented. Results of the study shows that students enjoyed the WBT style of teaching. They also said that it was a fun method and it kept them alert in class. The students preferred the WBT style than the usual lecture-discussion type of teaching.

Keywords: Whole Brain Teaching, academic performance, effectiveness, mean scores, science curriculum, General Chemistry I, pretest, posttest.

Introduction

Obtaining scientific knowledge entails locating information, determining what information is needed, determining where information can be discovered, and determining how information may be acquired. Understanding scientific knowledge, on the other hand, entails the synthesis and development of operational meanings from data. The goal of the science curriculum, according to the K to 12 Curriculum Guide Science (2013), is to produce scientifically literate citizens who are informed and active participants in society, responsible decision-makers, and apply scientific knowledge that will have a significant impact on society and the environment. Specifically, the science curriculum is designed to enhance three learning domains of the students. These are performing scientific processes and skills, understanding, and applying scientific knowledge, and developing scientific attitudes and values.

Therefore, policymakers and technocrats are thinking of the strategies and methods in order to cater to the unlimited needs of students, and the changing trends with the context of school life. On the other hand, the totality of K to 12 Basic Education Curriculum implementation particularly the Grade 11 Science gradually pushes through in its fifth year of implementation during the school year 2017-2018. However, the difficulty of the subjects integrated in all grade sciences increases relevant to its spiral progression.

Chemistry is the science subject taken by third year students under the Restructured Basic Education Curriculum which lasted school year 2013-2014. In the new K to 12 Basic Education Curriculum, chemistry is included in all the Junior High School sciences such that it reappears in progression as to different quarters of each junior grade level. For Grade 11, General Chemistry I is taught for second semester and for Grade 12, General Chemistry II is taught in the second semester too.

The second quarter of Grade 9 Science entitled "Matter" includes: a) Chemical Bonding; b) Variety of Organic Compounds; and c) Mole Concepts and Calculations. Furthermore, General Chemistry I is offered for Grade 11 students in their second semester of schooling. Since the topics in chemistry are primarily taught in abstraction by most of the teachers as to technicalities relevant to each lesson, sustaining the interest of the students to learn and transfer of learning foremost should be considered.

Students' motivation indeed, as seen by the researchers, is an important factor of tracking a good academic performance record by a student regardless of the subject's difficulty. According to Orleans, in a study funded by Hiroshima University, the condition of physics and chemistry education in the Philippines has recorded a recent substantive development. However, it is delimited because of the deficiency of facilities foremost by the abstraction of the concepts presented with each (Orleans, 2007). This view in an international perspective has been supported with the national results mainly enjoined with the performance results of each of the high schools in the school year 2012-2013 and 2013-2014.

It is crystal clear in the perspectives of the researchers that the difficulty of the subject can be traced five years back based on the academic records kept by the school. Low performance in abstract subjects like chemistry has also been reflected by the Mean Percentage Scores (MPS) targeted a percentage increase of 2% which were not obtained by Don Ramon E. Costales Memorial National High School (DRECMNHS) in the school years 2012-2013 and 2013-2014. The Mean Percentage Scores of chemistry students in SY 2012-2013 and 2013-2014 were 82.22 % and 81.12% which means it is a deficit of 1.1 % to attain the target of 2%.

Moreover, as the K to 12 Spiral Progression elevates across the levels, the Mean Percentage Scores obtained by science teachers of Grade 8 Science for school year 2013-2014 showed and reflected that chemistry, as incorporated in the third quarter, has the 2nd lowest MPS among others as an indicator of the readiness of Grade 8 Students to take up Grade 9 Science particularly chemistry as an integrated subject for school year 2014-2015. Moreover, the MPS obtained in the second quarter of school year 2014-2015 Grade 9 Science is the lowest among others, a predicament of the difficulty in chemistry as an integrated subject. Furthermore, the results of the 2015-2016 Diagnostic Test conducted among thirteen (13) Grade 9 Sections have shown that seven among the ten (10) items with the least correct responses are chemistry-based pre-requisite questions.

In the conduct of First Periodic Tests in General Chemistry I, for Grade 11 STEM students for school year 2016-2017 marked a mean score of 35.88 and 42.84 on the Second Quarter Periodic Tests.

These data attained simply reveals that mastery learning in chemistry was low due to factors that govern learning and teaching such as of lack of meaningful strategy to teach the subject. Low retention rate is an offshoot of the lack of meaningful experiences due to the traditional approach in teaching the subject. Lack of concrete conceptualization of lessons brought about by the uninteresting mode of instruction. Inadequate and inappropriate teaching aids is also one of the factors. It is in this premise where there is a need to look into possible ways and means on how the students of

DRECMNHS can acquire the skills, knowledge, and information that will enrich and enhance their performance particularly in General Chemistry I to be taught in Grade 11 on the second semester.

Whole Brain Teaching Style

Students of the 21st century are now totally different from before. The attention span for listening using the standard "lecture method" has been shortened and students have become impatient in just listening to their teachers. Thus, the need for an active learning situation, which made the researchers think of conducting a study on the effectiveness of WBT Style. The WBT has its framework built in the philosophy of Sir Benjamin Franklin which states "Tell me and I forget, teach me and I remember, involve me and I learn". WBT is a methodology that does not focus on assessments, instead focuses mainly on getting students involved in direct instruction. It addresses the use of project assessments versus formative and summative formal tests. The proponent of the methodology, Dr. Chris Biffle, gives emphasis that WBT can be adapted to any age level and any group of students in any place. The WBT uses the Big Seven steps which include "class-yes", "classroom rules", "teach-ok", "scoreboard game", "hands and eyes", "mirror", and "switch" (Biffle, 2013; Tipton, 2017).

"**Class-Yes**" serves as the attention-getter. The teacher says "class" in variations according to pitch (high-low), speed (fast-slow), repetitions (once-many), gestures (none-small-dramatic). However, the teacher varies the utterance of "class" and the students say "yes" in the same manner the teacher does it. To the teacher, it is an entertaining technique to gain students' attention. To the students saying "yes" amplifies the teacher's request for attention thus making this a program in students' brains to receive instruction. It is used to start the lesson, control the crowd, and interrupt class activity (Biffle, 2013; Tipton, 2017).

"**Classroom rules**" serves as an organizer. It refers to the five (5) rules the class must rehearse once a week as follows.

a) Rule 1: Follow directions quickly

b) Rule 2: Raise your hand for permission to speak

c) Rule 3: Raise your hand for permission to leave

d) Rule 4: Make smart choices

e) Rule 5: Keep your dear teacher happy! (Biffle, 2013; Tipton, 2017).

"**Teach-Okay**" is the whole brain activator. It follows the maxim "the longer the teacher talks; the more students are losing". The Teacher speaks briefly, using gestures, usually no more than 30 seconds to one minute. Then claps hands (one to five times) and say, "Teach!" The students repeat hand clap, and say "Okay!" Then they make a full body turn to their neighbor and, using gestures, they teach their neighbor what the teacher have just taught the class. While students are teaching each other, the teacher checks for comprehension. All students should be gesturing! Students listening, mirror the gestures of students speaking (Biffle, 2013; Tipton, 2017).

"**Scoreboard**" serves as the motivator. It keeps the students intensely involved. The teacher makes a smiley/frowny diagram on the front board with Teacher VS Students Challenger. When students are on task, mark a smiley point. Then point at them; they clap their hands and exclaim, "Oh, yeah!" When students are off task, mark a Frowny point. Then point at them and students lift their shoulders and groan, "Ughhhhh!" (Biffle, 2013; Tipton, 2017).

"**Mirror words**" is the class unifier. The class can deeply be involved in the lesson by holding up your hands, ready to make gestures. The utterance of the word "mirror" by the teacher shall be repeated by the students. They are expected to mimic the gestures of the teacher upon the delivery of the lesson. When the teacher says "mirror off", mimicking stops. The usage of this technique activates the motor and visual cortices of the students' brain. The highest memory retention can be attained if the motor cortex of the brain is engaged to do more than that of the Wernicke's area of the brain that focus more on talking thus leading to the lowest memory retention (Biffle, 2013; Tipton, 2017).

"**The hands and eyes**" is the focuser. This step is used at any point during the lesson when the teacher wants students to pay "extra attention" to what he/she is saying/doing. To begin this process, the teacher says, "Hands and Eyes!" and the students respond by mimicking the words and movements of the teacher (Biffle, 2013; Tipton, 2017).

"**Switch**" is the involver. This step is to be used with the "Teach-OK" step, while students are teaching it is imperative that the same student not teacher every time. Therefore, in order to get every student involved in the lesson, the teacher will direct the students to "Switch!" the students will respond by saying "switch" and the "teacher" of the group will rotate. In here, chronic talkers learn listening skills, and chronic listeners learn speaking skills (Biffle, 2013; Tipton, 2017).

Conceptual Framework

Whole Brain Teaching Style is framed from researches on how the brain works at its best especially on learning. According to Jill Bolte Taylor as cited by Hermann –Nehdi, page 38 in his book "*My Stoke of Insight"* and as retrieved from a file of WBT URL, "Although each of our cerebral hemispheres processes information in uniquely different ways, the two works intimately together when it comes to just about every action we take." Thus, current research suggests that the historical approach to learning, right brain, and left brain is no longer applicable. Whole Brain Teaching Style is framed further on constructivist point of view concerning Vygotsky's Social Learning theory. Therefore, putting the students in control of their own learning(Charles, I. & Chen, L, 2017).

This study came out for possible solutions to be undertaken in order to deal effectively in addressing the difficulties of Grade 11 STEM students particularly in chemistry. Likewise, it could help teachers in the secondary schools to identify appropriate classroom management and teaching styles that would eventually improve their learning effectiveness and efficiency in the aspects of their teaching strategies, techniques, and policies with regards to facilitating learning. Thus, the researchers thought it wise to conduct this kind of study, which is a common practical problem of all science teachers in the different junior grades and is being experienced now in the senior years.

In a meaningful deliberation of a lesson and in a teaching-learning situation, materials to be used must be an aid to facilitate learning. According to Jones (1979) in a file retrieved from WBT URL "Teaching should encompass different alternative delivery options (materials, media, and methods) allowing teachers to become facilitators instead of broadcasters of new information." WBT, in the 21st century classroom, incorporates music, dances, singing, chants, and technology-based projects. According to Lindstrom (2010), "The goal is to liven up lessons with zany and upbeat actions and sayings while placing a major emphasis on students and immediately re-teaching information to their peers." Whole Brain Teaching centers on the use of active learning and rituals in the classroom where students become the teachers and teachers become merely "facilitators of learning" (Charles, I. & Chen, L, 2017).

According to Tipton (2017), WBT is a new "radical" idea; however, it is nothing more than tried and true teaching practices, combined into a new approach. WBT combines direct instruction, sharing and immediate feedback to become a new style of teaching. WBT surmounts to seven steps that a teacher incorporates into his everyday classroom.

In the same article written by Tipton (2017), WBT is considered one of the best practices because this method of teaching seeks to empower students as learners. In most classrooms nationwide and worldwide, teaching remains direct instruction by a teacher who is "more knowledgeable" transferring knowledge through lectures and worksheets all leading to a test. However, whole brain teaching attempts to break away from this norm and allows students to become the "more knowledgeable ones" in control of teaching, while also taking attention away from tests and focusing on daily activities. Although there is no universal definition of a best practice, many companies/organisations believe that it is a research-based technique that has proven to be effective and can be repeated. It is along with this premise that the study explored the effectiveness of the WBT as a means to enhance students' performance in Grade 11 General Chemistry I.

A Gantt chart was used to show how the study was conducted. A Gantt chart, commonly used in project management, is one of the most popular and useful ways of showing activities (tasks or events) displayed against time. On the left of the chart is a list of the activities and along the top is a suitable time scale. Each activity is represented by a bar; the position and length of the bar reflect the start date, duration, and end date of the activity (https://www.gantt.com/). Table 1 draws the entire flow of how the research was conducted and led to the development of conclusions and recommendations by the researchers. The first column shows the activities conducted by the researchers. The second up to the fourth column shows the months and weeks that the activities were conducted.

The table shows that on the first week of month 1, pre-test was administered for both the control and experimental group. From the second week up to third week of month 2, students were taught using the traditional method for the control group and WBT for the experimental group. On the last week of month 2, a post-test was administered and the results were analyzed using the statistical treatment. After the analyses of the data, the effectiveness of the WBT style was determined and conclusions and recommendations were made by the researchers.

Table 1. Activities undertaken during the research study using a Gantt chart

Activities Undertaken	**Month 1**				**Month 2**				**Month 3**		
Week Number	1	2	3	4	1	2	3	4	1	2	3
1. Conduct of Pre-Test to Grade 11 STEM	■										
2. Stratified random selection of students for Control Group (to be taught using 4As) and Experimental Group (to be taught using WBT)	■										
1. Use of WBT for Grade 11 students using the following procedures.		■	■	■	■	■	■				
a. Preparation of the class by orienting the students on lessons/topics studied											
b. Usage of the WBT in Grade 11 Science Instruction		■									
c. Evaluation outcomes of instruction (Post-Test)			■	■	■	■	■				

1. Determine the mean scores by the post examination											
2. Analyse the data using the statistical treatment											
3. Determine the effectiveness of WBT by comparing the pre-test and post-test results											
4. Compare the effectiveness of WBT to 4As based on respective pre-test and post-test results											
5. Summarise the survey on the perception of the students on the WBT style											

OBJECTIVES OF THE STUDY

This study generally aims to determine the effectiveness of Whole Brain Teaching (WBT) Style in enhancing the academic performance of Grade 11 Science Technology Engineering and Mathematics (STEM) students of Don Ramon E. Costales Memorial National High School, Villasis, Pangasinan, Philippines in General Chemistry I. Specifically, it sought to answer the following questions: (1) Is there any significant difference between the performance of students taught using WBT Style and students taught using K to 12 4As [Activity, Analysis, Abstraction, and Application] in terms of their mean scores in their posttest? (2) Is there any significant difference in the mean scores change of the students after the WBT style is done? (3) What are the perceptions of the Grade 11 students in using the WBT style in teaching the lessons in General Chemistry I?

3.0 MATERIALS AND METHODS

This study used both quantitative and qualitative methods of research. According to Bhat (2017), "quantitative research employs strategies of inquiry such as experimental and surveys, and collect data on predetermined instruments that yield statistical data." Qualitative research, on the other hand, is defined as a market research method that focuses on obtaining data through open-ended and conversational communication. This method is not only about "what" people think but also "why" they think so (QuestionPro, 2018).

This study used stratified random sampling in determining the Pre-Test-Post-Test Control Group and Experimental Group. The control group was taught using the K to 12 4As (Analysis, Activity, Abstraction and Application), referred to as Class X while the experimental group, referred to as Class Y, was taught using the WBT style to look into the effectiveness of the latter in enhancing the performance of Grade 11 students of DRECMNHS in Science particularly in General Chemistry I.

3.1 Subjects of the Study

This study used Whole Brain Teaching (WBT) Style to enhance the academic performance of students of Grade 11 STEM in General Chemistry I in terms of their mean scores in the pre-test and post-test.

3.2 Statistical Treatment of Data

The activities undertaken by the researchers, the data collected and the statistical treatments used are shown as follows.

Table 2. Activities undertaken, data collected and statistical treatment used by the researchers.

Activities	Data to be Collected	Data Analysis/ Statistical Treatment
1. Use of WBT using the following procedure. a. Prepared the class by orienting the students on lesson/topic to be learned b. Used WBT to teach the lesson. c. After the WBT the teacher wraps up the activity d. Evaluate outcomes of instruction	Pre-test/post-test results for the Second Quarter	Paired Sample Test (T-test)
2. Establish the mastery learning by quarterly examinations.	Data on Quarter exams	Mean Scores Paired Sample Test (T-test)
3. Conduct a survey on the students for their perception of the WBT style.	Perception – using google form	Descriptive / Qualitative

To determine if there was a significant difference in the pre and post-test of the students and the degree of effectiveness of WBT, the result was tallied and was analysed at 0.05 level of significance.

RESULTS AND DISCUSSION

This study shows that the Whole Brain Teaching (WBT) Style is an effective instructional strategy that enhanced the academic performance of Grade 11 Science Technology Engineering and Mathematics (STEM) students of Don Ramon E. Costales Memorial National High School, Villasis, Pangasinan, Philippines in General Chemistry I.

As illustrated in Table 3, the control group, Class X, obtained a posttest mean score of 44.7200 while the experimental group, Class Y obtained a mean score of 51.6000. The mean score of the students taught using WBT style was higher compared to the mean score of the students taught using the K to 12 4As. Jensen (2009) said that there is a lot of evidencesuggesting there is a link between movement and learning, as well as movement and retention. Movement can be an excellent cognitive technique for (1) enhancing learner motivation and morale, (2) improving memory and retrieval, and (3) strengthening learning. This supports what happened in the academic performance of the students after administering the WBT style.

Table 3. Mean scores of control and experimental groups in their post-test or quarterly test.

n = 50

Class	Mean	N	Std. Deviation	Std. Error Mean
x	44.7200	25	11.75273	2.35055
y	51.6000	25	10.16530	2.03306

Table 4 shows a positive correlation of 0.408 and a level of significance at 0.043 which means that WBT style improves performance in terms of post-test or quarterly examinations. Table 5 also shows that WBT style in teaching improved the students' performance in terms of the mean scores change in their post-test. The mean difference was -6.8800 which means that the post test scores of Class Y, who were taught using the WBT style are higher than the post test scores of Class X

Table 4. Effect of WBT style in the performance of students in their post-test.

Class	N	Correlation	Sig.
Pair 1 x & y	25	.408	.043**

*** significant at 0.05 level * significant at 0.01 level*

Table 5. Mean scores change in the post-test of the students after the WBT style was done.

	Mean Score	Mean Difference	t-value	Sig (2-tailed)
X	44.7200	-6.88000	-2.866	0.009
Y	51.6000			

*** significant at 0.05 level * significant at 0.01 level*

Results also shows that students' pre-test scores improved significantly for Class Y after WBT style was carried out. Table 6 draws the mean scores of the pretest and post-test; a mean difference of -2.384 which means that WBT style improved the scores of the students; a positive correlation value of 0.515; and finally, a p-value of 0.000 which means that there was a significant difference in the mean scores change of the students after the WBT style was applied. This means that WBT style is an effective instructional strategy in improving or enhancing the academic performance of students in terms of pre-test and post-test scores.

	Mean Score	Mean Difference	r-value	Sig	t-value	Sig (2-tailed)
Pre	27.7600	-2.384	0.136	0.515	-10.173	0.000
Post	51.600					

Table 6. Mean scores change for the pre-test and post test scores of students taught using WBT (Class Y)

*** significant at 0.05 level * significant at 0.01 level*

After the conduct of the WBT style of teaching, the students were interviewed about their experiences on the teaching style. Most of the students enjoyed the WBT style of teaching. They also said that it was a fun method and it kept them alert in class. But some students also said that they were pressured sometimes because the WBT makes them think faster than usual. In an article written by Elmore (2017), she said that while this technique is ideal for kids who have experienced trauma, other students may find this method of learning to be overwhelming. If students have a timid, quiet, or sensory-processing-impaired pupil, this may not be the best technique for them. But generally, the students preferred the WBT style than the usual lecture-discussion type of teaching.

Conclusion and Recommendation

Based on the findings of the study, it may be claimed that the WBT style in teaching General Chemistry I is an effective instructional strategy to improve or enhance the academic performance of students in terms of their examinations. Also, WBT is an instructional strategy that is engaging and motivating since the students enjoyed this teaching style more than the K to 12 4As. It can also be concluded that learning can happen at the same time with fun and enjoyment and this is evident in the academic performance of the students before and after the implementation or application of the WBT style of teaching.

The researchers strongly recommend using the WBT style in teaching not only in General Chemistry I, but it can also be used in other subjects other than science. Also, it must be carefully planned as well, and it can be done even on a unit lesson. Varying the strategies per unit is also a suggestion to cater to the needs of the students. The researchers also suggest that teachers who will try to use this teaching style must learn to do it properly for it to become successful.

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2022
SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 2, No: 1, PP: 19-33
www.journal.qitepinscience.org
Research Paper
Open Access

Chemistry Reading Activity in Metacognitive Knowledge

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Abstract

An exploration of chemical reading performances of fifteen chemistry teacher candidates was conducted to reveal qualitatively metacognitive knowledge during chemistry reading activities. A think-aloud protocol had been carried out for reading performance, which is a technique to verbalise one's thought. For a question posing purpose, two articles were designed to stimulate the readers' thought in a metacognitive level that was divulged in-depth by self-interviewing questions. The reading performance was measured using the normal reading rate and think-aloud reading rate to reveal the pattern of chemical reading activities. A phenomenological reduction method was used to analyse and describe the reading performance. This study elicited that declarative knowledge was mostly used on the reading preparation, procedural knowledge in reading processes, situational knowledge on maintaining the reading activity, and strategic knowledge on the termination process. The four knowledge were constructed by the self-organisation, task comprehension, as well as strategy and knowledge to integrate every sources. The presence of chemical equations, chemical representations, and terminology on the chemical reading had influenced the chemical reading pattern. The successful chemical reading activity requires the readers' personal aspect and the strategy designed for understanding the reading.

Keywords: chemistry reading activity; metacognitive knowledge; phenomenological reduction; think-aloud protocol.

Introduction

Reading an academic article, like a chemical reading, simultaneously produces cognitive and metacognitive activities in one's self (Khezrlou, 2012; Korpershoek, et al., 2015; Leopold & Leutner, 2015), due to some mental activity in the mind. These activities are elaborating retention time and performance, detecting errors in prior knowledge, and sorting symbols in readings (Eitel & Kuhl, 2016; Garcia-Rodicio & Sanchez, 2014; Green & Redford, 2016). While reading, one finds knowledge structures in texts with a sophisticated epistemological belief (Norris & Phillips, 2012). If someone is in this belief mode, someone will show some metacognitive behaviours such as choosing strategies for understanding, applying prior knowledge to solve problems, and checking progress consistently (Pulmones, 2010). Through posing questions after the reading activity could become an indicator to reveal both cognitive (Demirdogen & Cakmakci, 2014) and metacognitive level related to one's understanding about the chemistry and the context of the reading (Ghasempour et al., 2013; Herscovitz et al., 2012; Kaberman & Dori, 2009).

This metacognitive aspect is difficult to observe since the process occurs inside one's mind (Dunlosky & Metcalfe, 2009; Grotzer & Mittlefehldt, 2012; Schraw et al., 2012). A problem faced when one would study metacognition was the fuzziness of its terminologies that seemed on the various components and their relation to each other (Zohar & Dori, 2012). In terms of metacognitive knowledge, some experts viewed it as the aspect of cognition (Eldar et al., 2012; Flavell 1979), while others said it contained some dimensions of knowledge (Favieri, 2013; Sperling et al., 2004). This case became more difficult to understand since it was added by some partial studies of its components (e.g. Chiu & Linn, 2012; Handel et al., 2014; Marulis et al., 2016; Molenaar et al., 2014). These partial studies elicited complications in studying metacognitive knowledge as a complete process in a learning activity. Therefore, this study will try to handle this case by analysing the whole component of metacognitive knowledge.

Exposing metacognition could be easier when using a think-aloud protocol (Herscovitz et al., 2012; Kaberman & Dori, 2009), which is a technique to verbalise one's thought (Jacobse & Harskamp, 2012). The benefit of this technique is to give the sight of process of memory and actual thinking when one is reading, understanding, strategising, processing, and deciding (Charters, 2003; Overton et al., 2013; Wilhelm, 2001) for revealing the metacognitive strategy, metacognitive judgment, and metacognitive knowledge (Ben-Eliyahu & Bernacki, 2015; Binbarasan-Tüysüzoglu & Greene, 2015). A phenomenological study could get a whole description of those metacognitive phenomena (Thomas & McRobbie, 2013; Vierkant, 2017). This research is conducted to explore phenomenologically the metacognitive knowledge in the reading activity of a chemical article from a think-aloud activity for a problem-posing purpose.

Research Method

2.1. Context and participant

This was a qualitative study of 15 undergraduate students that were chemistry teacher candidates in their third years at a public state university in Yogyakarta, Indonesia. All of them were females between the age of 19 to 21 years old. They were in the international programme that used Indonesian Language and English (bilingual class) during their courses. All participants had obtained the basic chemistry course in the first year and the chemical equilibrium course in the second year. They participated voluntarily in this research outside the regular class activities. Ethical consideration was used to protect the data of participants (Sadowski & McIntosh, 2015; Taber, 2014) which was stamped in an agreement between each participant and the researchers. The participants were encoded by letters A to O.

2.2. Instruments

Two chemical readings had been designed to stimulate the metacognitive strategy in the reading activity. The first reading was an article about the application of chemical equilibrium in human teeth. The second reading was about chemical equilibrium in esterification. Those articles were arranged overlapping with other chemistry domains and other disciplines, that fulfilled some criteria about the chemical reading as mentioned before, to stimulate the participants as readers in order to pose problems in question-form at metacognitive level. The articles had been validated by two experts in related disciplines, and some suggestions form the experts had been used to consummate the reading.

Moreover, there were 39 questions of metacognitive knowledge exploratory arranged to reveal another metacognitive aspect that was not observed during the reading and posing question activities. The questions were made based on the component of metacognitive knowledge dimension on Table 1. The questions were open-ended questions and had been validated by two experts on chemistry education and psychological education. Some suggestion from experts had been used to complete the questions' visibility.

Table 1. Matrix of Interrelation Component of Metacognitive Knowledge Dimension

	Declarative (what)	Procedural (how)	Conditional-Situational (why)	Conditional-Strategic (when)
Person	Strength; weakness; motivation; anxiety	Making assumption; interaction with others (team) for solving problems	Believe positively to the things conducted; organize the strength; control the anxiety; and boost the motivation	Believe positively to the things conducted; organize the strength; control the anxiety, and boost the motivation
Task	Information given; goal, information sources needed; skills needed	Using the sources; organization of the sources	Check the appropriateness of the method; check the accomplishment of the goal	Check the appropriateness of the method; check the accomplishment of the goal
Strategy	List the methods that can be conducted; select the method; organize the skills; control the learning process	Ways to finalize the procedure; ways to apply the procedure; ways to conduct the procedure in different situation	Use certain methods in learning; conduct the procedure sequentially on the task completion	Use certain methods in learning; conduct the procedure sequentially on the task completion
Integration knowledge	Identification of the strategy towards the task by considering the strengths and weaknesses	Implementation of the strategy chosen on organization of task completion by considering the assumptions	Analysis of completion process conducted towards the appropriateness and accomplishment of the task based on self-judgment	Evaluation of completion process conducted towards the appropriateness and accomplishment of the task based on self-judgment

2.3. Procedure

A think-aloud protocol was used in this reading procedure for collecting data about metacognitive activities during reading the article. First, each participant was given the article and had been given a simulation of the procedure of think-aloud for recording. Each participant had been requested to vocalise or verbalise their thoughts in front of the recorder during the reading time. There was no pause activity during reading, posing the question until answering the questionnaire. For validating the think-aloud technique as mentioned by Overton et al. (2013), the reading activity was conducted one-by-one (not in a group), without researchers' interruption, at the comfortable place that the participant selected before, and in their spare time.

Before each participant began to read, they were asked about some terminologies of chemical equilibrium that had become the problems in understanding about the chemical equilibrium. These terms are chemical equilibrium, dynamic equilibrium, heterogeneous equilibrium, chemical equilibrium constant, Le Chatelier principle, chemical equilibrium shift direction, and gaseous equilibrium. These terms were selected because they tended to undergo some systematic error and random error (Atasoy et al., 2009; Ozmen, 2008).

The first reading activity was conducted for the first article by self-interviewing which the participants should answer the 39-questions by their own self. Each participant answered the preliminary term-question, read the article, arranged their two-problem, and interviewed themselves used an audio recorder. A month after the first test, the second test was undertaken for the second article. The test was begun with preliminary term-question. Nevertheless, the metacognitive knowledge exploratory questions were given by the test instructor to the participants specifically (the questions).

Data recorded about the reading activities, question-posing activities, and self-interview were recorded by participants' approval. Audio and paper-based documents were encrypted by special code to enclose participants' data. Transcriptions of data were checked by the participants and independent reviewers to inspect the time accuracy of each passage segment and the word precision of the think-aloud activity. Coding data of the analysis were verified through a focus group discussion with the experts related.

2.4. Data analysis

The data collected were transcribed chronologically and validated by the participants. How they read the articles was transcribed and marked in the specific coding consisting of the reading pattern and reading parameters. The transcription was arranged embedding and sequentially between the textual word and think-aloud word. Every segment (sentences, equations, and figures or graphs) was measured to the reading rate as think-aloud rate. The rate was converted to reading pattern graph for each reading activity. A normal reading rate was determined as the total words on the text divided by the time consumed. The difference between the think-aloud rate and the normal rate was represented by delta.

A phenomenological reduction method was used to analyse the reading phenomena (Atasoy et al., 2009; Chopra et al., 2017; Ozmen, 2008; Sadowski & McIntosh, 2015). All data were reduced (horizontalization of data). It was carried out by deleting the statements of think-aloud expressions that were not related to the activities on each parallel segment of reading the article, posing the questions, and answering the questionnaire. After this reduction, the data would be encoded and categorised in the same theme that represented the specific expressions and findings of metacognitive strategy in the reading activity of the chemical article. The coding from the reading pattern was used to find "neomatic" themes (what the phenomenon is) and the coding from the think-aloud activity and self-interview was used to find "neosis" themes (how the phenomenon is). Then, data verification was conducted to clarify and reinforce the themes. The "neomatic" themes were unified as a formulation of the textural definition, but the "neosis" themes were as the structural definition. By blending the textural and structural definitions and adding with data interpretation, the themes were merged to be the essential definition of metacognitive knowledge in chemistry reading activity.

Results and Discussions

3.1. What do I prepare for reading activity?

The first article was more contextual for the participants than the second one. However, the second article was closer to the participants' expectations rather than the first one. According to the participants, when they knew that they would read the article about chemical equilibrium, their mindsets had predicted that the article would be full of formulations, integral, derivative, and nominal data. They confessed that all of them had a similar perception of the topic, and they had some difficulties mastering it during the first year. The quotation below showed this perception (the quotation is translated from Indonesian Language).

A: *yeah, I don't know, I mean, eh... the chemical equilibrium tends to the computation, doesn't it?*

B: *In my idea, this chemical equilibrium will contain thermodynamics or many numeric data such as temperature, volume, etc. I have been so confident but the text was different towards my expectation.*

But this perception was reduced by their curiosity and motivation to confront the challenge. They called this reading so challenging because they usually read voiceless and they predicted that it would be not easy as usual as they read.

At this step, the declarative knowledge held the important thing to start the effective reading to reach the goal. As the readers, there were two types of reading planning styles conducted by these participants, which were organised-preparation and dilapidated-preparation. The organised preparation was a strategized reading planning that was conducted by students to reach the goal. In this style, the students began to recognise the detailed thing they faced (task), and then they asked themselves about what they had (person), what they should do (strategy), and what they needed for reconsideration before undertaking the reading (knowledge integration). The dilapidated preparation was an unsystematically independent style in designing the action for reading. This style began to recognise the important thing they faced (task), then they try to get something familiar from themselves (person) to determine the simplest way (strategy) by reconsidering some advantages (knowledge integration).

The style selected by ones for this chemical reading activity depended on their habit of reading in general, perception of the task, and estimations about themselves. Habits were more impactful than others because they tended to do what they usually do. The voiceless reading habits tended to be more difficult to undertake in this think-aloud protocol. Their perception of the reading's topic-chemical equilibrium-was shaped by their experiences and the preliminary insights about it. Their difficulties while studying the chemical equilibrium contributed to the uninteresting perception of the text, even though they had not read the text yet (had no idea about the text). These difficulties also made them underestimate and judge themselves because the reading was not understandable.

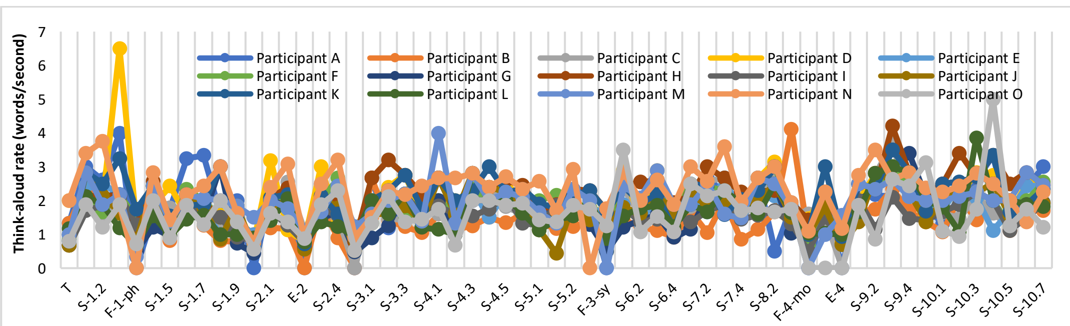
3.2. How do I read?

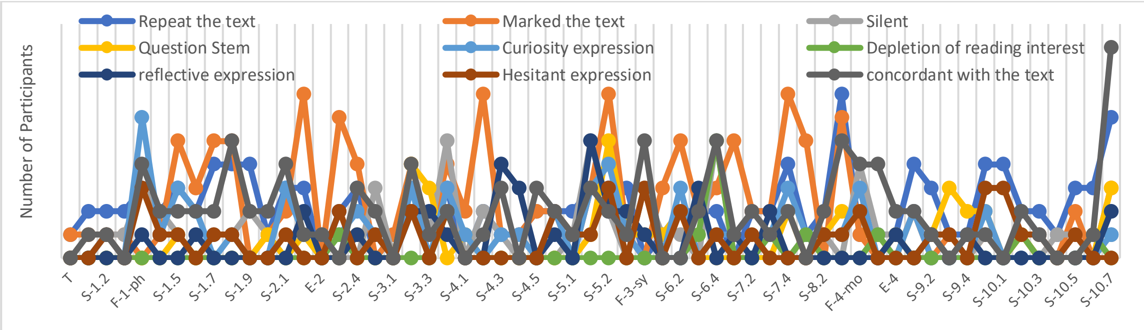
There were three applicable methods for their preparation in chemical reading activity, which were curious-based, visual-based, and continuous-based. The method selected determined their procedural knowledge during the reading performance. The curious-based reading style was undertaken by students that had higher curiosity towards the chemical aspect in the article, as limited as in-context about the text. The visual-based style was a combination of the imagination and cohesiveness towards the chemical aspect of the article to the contextual experiences. The continuous-based style was used by students that thought the simple ways to get a whole understanding of the article. The style selected by participants did not impact the propriety and correctness of the result of the chemical articles reading performance.

The selected style depended on their understanding of declarative knowledge, and their interest in chemical readings. Declarative aspects discussed before determined how one should position themselves to undertake the chemical reading performance. The process-oriented participants who liked to improve insights tended to select the curios-based style (participants C, D, F, G, J, L, and M). The process-oriented participants who relished on the contextual and representation preferred to visual-based (participants I, K, and O), while continuous-based was preferred to the result-oriented participants (participants A, B, E, H, and N).

The detail of the reading pattern of the first article was shown in Figure 1. In the figure, the trend of decelerating the reading rate was undertaken by the chemistry teacher candidates, in all reading performance styles, all chemistry representations (phenomenology, symbolic, and model figure separately), and all chemical equations. The phenomenological representative showed the context of the reading and conveyed to the readers the things that were discussed in the text. Some participants (like participants B, C, D, I, and L) determined the phenomenological figure as the starting point for reading performance. There were two phenomenological representatives on the first reading: (1) at the beginning or first paragraph (the 56th word); and (2) in the middle or in the fifth paragraph (the 509th word).

Figure 1. Think-aloud of Reading Pattern (up) and Reading Expression (down) for Article 1

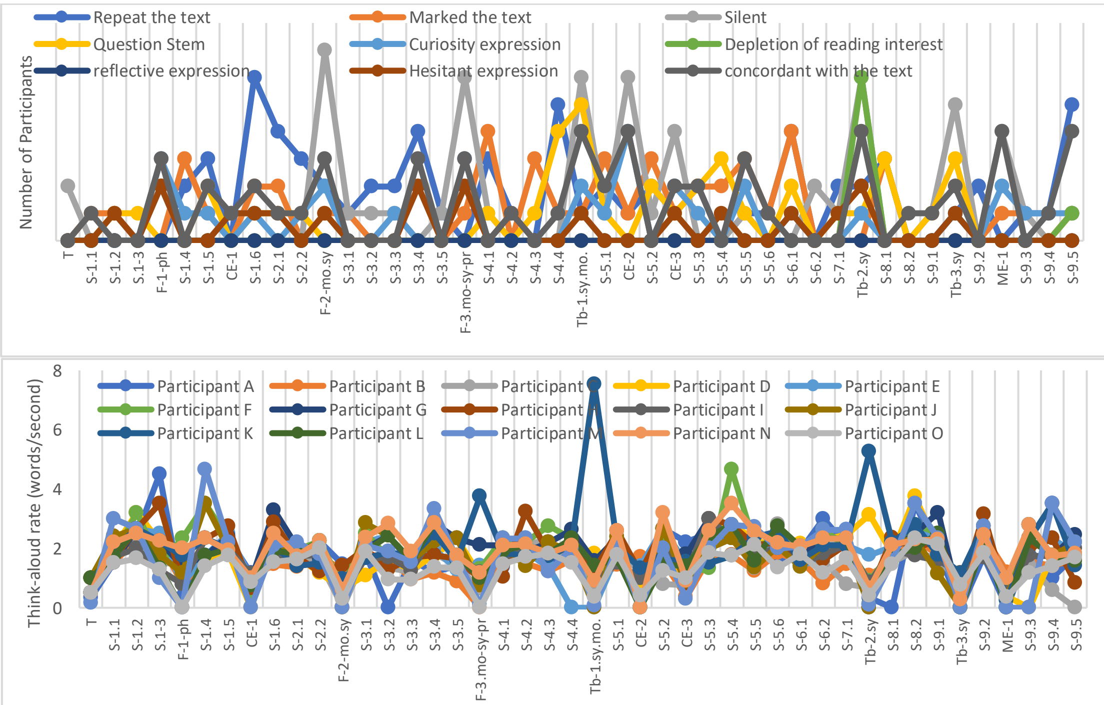




Note: the abbreviation T (title), S-X.Y (on paragraph X sentence Y), E (equation), and F (figure: 'ph' for phenomenology, 'sy' for symbol, and 'mo' for model

The phenomenological figures had stimulated the reflective expression for all reading performance styles (compared to Figure 1). By phenomenological representative, the reader could compare the experiences and preliminary insight related to the information on the figures. These reflective expressions were followed by curiosity expressions, as shown in Figure 2. The graph indicated that the expressions were not undertaken by all participants. Some less think-aloud participants did not voice and stay on silent while understanding the phenomenological representatives.

Figure 2. Think-aloud of Reading Pattern (up) and Reading Expression (down) for Article 2



Note: the abbreviation T (title), S-X.Y (on paragraph X sentence Y), E (equation), and F (figure: 'ph' for phenomenology, 'sy' for symbol, and 'mo' for model

The decelerated reading rate on chemical equation was not followed by the increasing of reflective expression. The chemical equations were accused the chemical reading itself. On these chemical equations, all expressions were also decreasing. For these participants, how to vocalise the chemical equation was out for appreciation. Although they were the chemistry teacher candidates, they had some difficulties to vocalise the chemical equation. Most of them confessed that they often observed and analysed mentally on their mind. For examples, the equation from first article (E-1 and E-2) and second article (CE-1) as followed (all think-aloud activities are translated from Indonesian Language).

[E-1] $Ca_5(PO_4)_3OH(s) \rightleftarrows 5Ca^{2+}(aq) + 3PO_4^{3-}(aq) + OH^{-}(aq)$

(Type 1) $Ca_5(PO_4)_3OH$[spelling by letter](*solid*) have an equilibrium with $5Ca^{2+}$[spelling by letter](*aqueous*) plus $3PO_4^{3-}$[spelling by letter](*aqueous*) plus OH^{-}(*aqueous*)

(Type 2) Oh, equilibrium. Is it the dissociation reaction to be its ions?

[E-2] $Ca_{10}(PO_4)_6(OH)_2(s) + 8H^{+}(aq) \rightarrow 10Ca^{2+}(aq) + 6HPO_4^{2-}(aq) + 2H_2O(l)$

(Type 3) $Ca_{10}(PO_4)_6(OH)_2$[spelling by letter](*solid*) plus 8 H^{+}[spelling by letter] (*aqueous*) oh acid, becomes $10Ca^{2+}$[spelling by letter](*aqueous*) plus $6HPO_4^{2-}$([spelling by letter] (*aqueous*) and water.

[CE-1] 

(Type 4) RCOOH group, reacted with R'OH, it is alcohol, catalysed by H_2SO_4 produce RCOOR' and water

Type 1 showed that the reader just only read the symbols by spelling the letters of chemical compounds. On type 1 of the chemical equation think-aloud, some participants only read the compounds without the substance's phase. The puzzling things for readers were how to spell the double forward-reverse arrow and how to spell the chemical names of the compound. The fuzziness encouraged the readers to remain silent. Type 2 showed the reader voiced about their interpretation of the reaction. This second type was undertaken by critical-think-aloud readers because they thought that the way they interpreted the reaction was more important than how to spell it. The silence before interpreting this equation was conducted to arrange the knowledge about the reaction by seeking for the familiarity and connecting each insight. Type 3 was the combination of type 1 and type 2. This third type just only interpreted the common and important symbols of the reaction as such H^{+} for the acidic condition, OH^{-} for the basic condition, H_2O for water, etc. The interpretation was limited to what the reaction is (not on how the reaction occurred). Type 4 occurred in a specific chemical reaction such as it had a structural formula form, an additional treatment (e.g. catalyst, temperature, and heat), etc. The fourth type of the chemical equation think-aloud was also observed on CE-2 and CE-3 that had similar presenting style (see Figure 2). When the chemical equation was combined with the model or the structure of a compound, some mental processes occurred in readers' mind to identify and visualise the process that may be existed towards the reaction.

The symbol in the first article showed that it had a lower curiosity expression than the model and the phenomenology. The graph presentation was less interesting compared to the diagram of a chemical. The second article combined some representations to be a figure. Some metacognitive expressions were detected in the think-aloud of the combined representations in the second article. Table 6 gave the example of the think-aloud of participants G, H, and I as the representatives for each reading performance style. The continuous-based (participant I) showed that the participant had a similar reading pattern both on the dependent and independent chemical combined representations. The result-oriented (participant H) did not change their strategy on reading when finding the chemical representation. The curious-based (participant G) indicated that the think-aloud expression increased towards more dependent combined representations. By understanding the model figure, it was considered as an inhibitor in reaching the goal (question-posing) because it wasted time. The reading rate of the three dependent representations was the lowest compared to the independent and two-dependent representations. The dependent chemical representation could help readers interact with the passage and construct the knowledge from the text. For the visual-based, comparing the information to the experiences was undertaken while they were reading slowly. When they did not find similar experiences, they just only concurred with the information they read and thoroughly searched for an explanation about the figures in the text written.

Back to the Figure 1 and Figure 2 that some decelerating patterns that indicated the interesting reading spot for readers were observed on S-1.5, S-4.2, S-6.2, S-6.4, S-7.4, S-9,5, and S-10.2 in the first article (Figure 1) and on S-2.1, S-3.3, and S-5.5 in the second article (Figure 2). The decelerating on S-1.5, S.4.2, and S-9.5 was affected by the numerical data given in the text. The readers thought, numerical data were important to understand the text, especially in chemical equilibrium, since on their perception before that the chemical equilibrium related to computations, equations, and numbers. The other spots (S-1.5, S-2.1, S-3.3, S-5.5, S-6.2, S-6.4, S-7.4, and S-10.2) drew attention from the readers by the terms mentioned in the texts. When they found the unfamiliar terms, they decelerated their speed on reading and took more attention to find the explanation of the terms mentioned. In Figure 1, the spots mentioned were marked by the readers as the important parts of the text. In figure 2, they were not marked because the terms were familiar, even they found another insight about them.

3.3. Why do I keep to read?

There were some reasons that made the readers keep reading the article based on their style until the end. In this case, conditional-situational knowledge acted on why they conducted the reading performance. By this conditional knowledge, the readers had regulated their sources on declarative knowledge to the performance on procedural knowledge. The reasons of readers keep reading was influenced by some impetus factors to the chemical reading. There were three types of the readers based on the impetus, which were an inquisitive-reader, an obliged-reader, and a challenged-reader. Table 2 shows the characteristics of each reader type.

Table 2. Reader Impetus of Chemical Reading in Conditional-Situational Knowledge

Factor Impetus	Inquisitive Reader	Obliged Reader	Challenging Reader
Nature	Understand chemical information based on the curiousness	Understand chemical information based on the task demand	Understand chemical information based on the eagerness
Task comprehension	Focus on the technique required	Focus on producing the questions	Focus on simplifying the instruction
Belief	I start to finish well	The result's correctness is not important	My will is I must try
Self-empowerment	Using the dominant strength that is curiousness, defeat the anxiety	Prohibiting the laziness to cover the weakness is responsible for the task	Be calm to control the anxiety
Strategy organization	The difficulties towards the text comprehension function to be the alert for the question posing	Finishing the reading is the only way to finalize the task for the question posing	I do not know the task definitely but I know what I have to do, just keep to read

First, the inquisitive reader referred to the readers who kept going on reading because their curiousness about the article guided them in seeking knowledge. This reader style was motivated by a wish to measure themselves. This style endeavoured to accomplish the task given and to return the paper not blank. Second, the obliged-reader implied to the reader who was burdened by the responsibility to accomplish the task given. This style was used by the readers who had not enough strength in the question-posing. A little bit of curiosity combined with the responsibility to conduct the task pushed them to keep reading. Last, the challenged-reader was the reader who desired to face the challenging task. This reader liked something new for them and tried to get out from the comfort zone of the knowledge for new experiences.

The five impetus factors composed the specific strategy that the readers executed during the reading performance. During reading, the readers monitored their mind about the information read. By checking their reading performance, they could judge the propriety of their understanding towards the reading methods and the goal. The higher conditional-situational knowledge readers should check their reading to make sure the precision of the reason on why they keep reading. Moreover, it would be carried out in order to change the strategy if the previous strategy was not effective. This checking was verified by considering the time used and the time left.

They would accelerate their reading rate if the readers considered that the time left was minimal, the text was not important to understand in-depth, and after linger on the text that needed extra time for grasp such as on chemical equation, representative figures, numerical data, and terms' explanation, as shown in Figure 1 and 4. They would elucidate their voices if they thought the first voice was not clear for themselves and for the instructor, or if they wanted to emphasise the marked things in the text. Figure 1 and Figure 2 showed some marked text spots in each article and compared to Figure 1 and Figure 2 gave a trend on decreasing of the reading rate.

They would decelerate their reading rate if they found the interesting things and essential information in the text. They would speak louder if they realised their voices weaken and the recorder went far from the mouth. Some louder voices indicated some metacognitive expressions about the text such as hesitant expressions and concordant expressions. Analysis of Figure 1 compared to analysis of Figure 2 indicated that the louder voices were not only increasing the speed but also decreasing the speed. These louder voices not only expressed the emotional statement but also emphasised the important things about the text based on the readers' perspective. The readers would be voiceless if they were puzzled to speak their minds. Figure 1 and Figure 2 showed some silent spots when reading. For the first and second articles, the most of silent spots were on chemical representative figures, chemical equations, and mathematical equations.

They would select to read sequential or not depending on their self-judgment about their organisation strategy. They confessed that they read sequentially in order to be more structured, clearer, chronologic, not overlapping, and proper to the procedure. Some participants stated the sequential reading performance had been indoctrinated from the past. The non-sequential reading pattern is found in the phenomenological figure presented on the first page of the text. The phenomenological figure drew the readers' attention very much. Other non-sequential patterns were found on the surrounding of chemical representative figures and chemical equation. The quotation below showed the reason of a reader to read non-sequentially.

B: *I do not read sequentially. I jump from this sentence to another sentence. Because my memory was not too good. So, I cannot remember directly it. I forgot the discussion in this sentence. So, I read again at a glance to find some hints about it. So, my mind jumped to one spot to another spot.*

Some readers confessed that they did not check their reading because after finding the question, they were hesitant on their question but they did not know about the method to determine the propriety, even they did not think that they should check it. They did not reconsider their understanding of the task instruction and the text. The higher conditional-situational knowledge should reconsider their reading performance to make sure their reason to keep on reading. They would re-read again and check the goal.

This re-read activity observed in Figure 1 and Figure 2. The repeat spots were obtained on the long sentences, terms' explanation, numerical data, some representatives, and some equations. This re-read activity also contributed to the time consumed by the chemical reading activity. Maximum contributions (≥ 15%) were given by S-1.5 (terms and numerical and chemical data), S-1.8 (terms), S-2.1 (terms), S-3.4 (numerical data), S-8.3 (terms), S-10.1 (terms), and S-9.5 (numerical data and explanation) [Note: Repeat contribution was ratio of delta to normally relative reading rate]. The data implied that the more data about terms (and their explanation), chemical information, and numerical data on the chemical reading, the more time consumed as the contribution of repeat spots or re-read activities for more understanding towards the text. This case indicated to design the chemical reading activity, the repeat spots that were marked by chemical terms, numerical data, and important terms in the text that should be determined on time allocation given.

3.4. When do I master the reading?

Mastery reading was not only about the reading termination in the last sentences but also about the transition process from one idea to another in each sentence. The conditional-strategic knowledge acted in this domain, and not all participants had conditional-strategic knowledge of these chemical reading activities. Although they did not know, the conditional-strategic knowledge aspects were important and imperative to finalise their reading activity. As mentioned before, the nature of reader style had three types of strength empowerment, which were curious for inquisitive readers, eager for challenged readers, and merely obedient to obliged readers. These strengths were used by the readers to know when they mastered the whole reading or the partition of the reading.

There were five transitions found in these chemical reading activities. The first transition was from the preparation to the reading process. This transition occurred as the omen when the readers mastered the framework of the task (what the initial state was and what the final state was). This transition was important for the reader to design the strategic reading performance. The readers considered the task to the personal aspects (strength, weakness, motivation, and anxiety). All reader styles used curiousness to motivate them for chemical reading performance. The quotation below indicated the importance of motivation on chemical reading performance.

C: *if my motivation is too high, I would make the question rapidly. Although it could occur the misconception between the question required and the question posed. So, I decrease the anxiety and keep the motivation naturally.*

M: *if my motivation is too high in the beginning, I would have the full concentration to understand the idea of the text. If I had understood, so the curiousness will be appeared by itself. It means that my motivation should be wholehearted early*

The second transition was transition intra-to-inter-sentences. This transition occurred word-by-word from one sentence to another sentence. This transition was among the known things, the unknown things, and the important things. As discussed before, the things were chemical information, numerical data, terms and their explanation, and chemical representative figures. Figure 1 and Figure 2 showed that the things increased the concordant expression and the curiosity expression towards the text. Marked spots on the readings were understood as the important things emphasising the understanding of the unification of the idea discussed.

The third transition occurred from sentence-by-sentence in a paragraph to all paragraph in the text. This transition consisted of the iterative process of reading, capturing the idea in the text, and connecting the information with experiences and/or the preliminary knowledge. The iterative process in reading was observed in intra-sentence and inter-sentences. Figure 1 and Figure 2 had shown the intra-sentence iteration of these chemical reading performances as the function “repeat text”. Iterations of the inter-sentence in the first article were observed on T to S-1.4 (phenomenology figure), S-1.7 to S-3.1 (terms, chemical equations, numerical data, and process-micro of model representation), S-5.3 to S-6.1 (symbol chemical representative), and S-8.1 to S-9.1 (terms, model chemical representative, and chemical equation). Iterations of inter-sentence in the second article occurred on S-

3.1 to S-4.1 (explanation to the dependent chemical representative), S-4.4 to S-5.2 (explanation of the table of symbol and model representatives, the mathematical equation and the chemical equation), and S-9.1 to S-9.5 (explanation of the table of numerical data and mechanical equation). The spots implied that the iterations of inter-sentences were stimulated by the chemical representations.

A negative contribution of iterations (iteration contribution was the average of repeat contribution of all segments on iteration spot) was found in symbolic and model representatives, with or without chemical and mathematical equations. This case implied that all participants, as chemistry teacher candidates, had not enough think-aloud on dependent and/or independent chemical representatives of model and symbol levels, and had not enough interest to chemical and mathematical equations. The problems could be impacted by their chemical literacy towards the reading and their interest in the topic given**.**

The fourth transition was the diversion of reading process to the task climax, posing the question. The discussion of this transition was limited to reading performance of the readers. This transition consisted of making the question candidates, arranging the question, and examining. The reading activity on this transition was observed in Figure 1 and Figure 2 as "question stem". Some question stem spots were interesting to the readers. In the first article, these spots were on S-3.2 (detail information), S-3.3 (detail information), S-5.2 (terms and additional information), S-6.2 (terms), S-8.3 (terms and additional explanation), F-4.mo (model figure), S-9.3 (information), S-9.4 (explanation), S-9.5 (numerical data), and S-10.7 (include and suggestion). In the second article, these spots were on S-1.5 (terms ad explanation), S-4.4 (information), Tb-1.sy.mo (symbol-model data), S-5.2 (terms), S-5.3 (additional), S-5.4 (terms and explanation), S-6.1 (numerical data), S-8.1 (additional information), and Tb-3.sy (numerical-symbol data). Almost all spots had a similar tendency for their speed reading. The question spots which had the terms or related aspects of the chemical equilibrium, as the requirements of the question should be posed, were related to the reaction rate (S-3.2, S-3.3, S-4.4, Tb-1, S-5.2$_{\text{article-2}}$, S-5.3, S-5.4, S-8.1), contextual and daily life (S-5.2$_{\text{article-1}}$, S-9.3, S-9.4, S-9.5, S-10.7), chemical terms (S-6.2, S-1.5), chemical process (S-8.3, S-6.1), model representative (F-4). These spots indicated that the explanation about the task instruction was required, and the preliminary knowledge about the chemical topic was imperative for their chemical reading activity. These metacognitively chemical reading activities that conducted think-aloud protocol and question-posing had revealed the readers' conception of the gap between their old-item knowledge to the new-item knowledge from the text given. Thus, these reading activities could be the metacognitive stimulators for the assessors or teachers to know the problems in their learners' minds about the chemical topic.

The last transition occurred to the termination of the task. This was the last action of readers to claim that they had mastered or they had not mastered the chemical reading activity. The readers should regard that mastery the chemical reading activity was not only limited to the reading itself but also directed to the attainment of the reading purpose itself. The reason was that the reading activity was still on-going during the question posing. Some judgments to make sure the question posed were considered by the re-read-activity for a specific purpose. This re-read activity was skipped for reviewing the important information, searching the idea (when blanked in their mind or found no question candidate), and connecting some idea. By using their strengths to motivate themselves (when they were anxious, oppressed, puzzled, pessimistic, and frustration) the termination process of reading was controlled to finalise their chemical reading activity. Figure 1 and Figure 2 showed the motivation depletion on chemical reading activity. For the article 1 was observed started from S-2.3 (237 words), S-3.4 (318 words), S-6.3 (635 words), S-6.4 (661 words, peak for the motivation depletion), S-7.3 (721 words), S-8.1 (785 words), S-8.4 (859 words), S-10.2 (992 words), and S-10.5 (1046 words). For the article 2 was observed from Tb-2.sy (608 words, peak for the motivation depletion) and S-9.5 (855 words). These patterns showed that the motivation depletion reached a high point on 608-661 words read. In-depth observation of these motivation depletion spots revealed the factors affected this depletion. They were passing more than one chemical equation; facing the very long coordinated sentences; facing the sentence containing many numerical data, symbols, equations, and terms; finding the cardinal number marked to more than one discussion about the topic (e.g. a think-aloud for S-7.2 [*First, the weakening of acid potential ...*] the word "*First"* gave the perception on the reader that there will be the second, the third, and so on till they did not know); and finding the difficult chemical representative for understanding such as a model figure (e.g. S-8.3).

Thus, each transition had a specific effect on conditional-strategic knowledge in the chemical reading activity. The readers thought that they had mastered the chemical reading when they confirmed themselves according to the omens in each transition state. Confirmation of their prediction about their understanding could be checked based on their posed questions. Their strategies used during the chemical reading performance would be an important determinant for the quality of their understanding of the chemical reading metacognitively. This proficiency in reading performance originated from the self-efficacy beliefs which were the sources used by the teacher candidates while studying, reviewing, and strategising chemistry learning (Uzuntiryaki, 2008) and were shaped by advanced personal epistemology (Bahcivan & Cobern, 2016).

CONCLUSION

Reading chemical articles by metacognitive tasks, like conducting a think-aloud for a question-posing, is a stimulator for metacognitive activity. Every step of this reading activity entails an interrelationship between metacognitive knowledge domains. Declarative knowledge is involved while preparing for the reading activity. Conducting the reading activity is executed by procedural knowledge. Staying to keep on the reading activity requires conditional-situational knowledge. Then, terminating the reading activity is decided from conditional-strategic knowledge. Each step needs the harmonic collaboration from the reader (person), task comprehension, strategy organisation and knowledge integration about the action to do.

In summary, the successful chemical reading activity requires the readers' personal aspect to maintain their interest, motivation, perception, and correct interpretation of the task required. This is the capital to have adventures in the chemical reading activity. The strategy is designed for understanding the reading as well as integrating the understanding of the knowledge they have. The chemical reading itself should fulfil some specific requirements for stimulating the metacognitive knowledge on all aspects.

Acknowledgements

Thank you to Indonesian Endowment Fund for Education (LPDP) for funding and supporting this research.

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2022
SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 2, No: 1, PP: 34-38
www.journal-qitepinscience.org
Research Paper
Open Accsess

The Model of Physics Experiments Using Smartphone Sensors in Senior High School 1 Pangkalpinang

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Abstract

The aim of this research is to report the development of a physics experiment model for high schools by utilizing sensors on smartphones as devices for collecting of observing data on physics experiments to increase students' level of understanding. The research method used is research and development. The teacher arranges the physics experiments manual so that students can use it. Retrieval of data in the experiments uses the Research Based Learning (RBL) method so that students have the freedom to be creative in using smartphone sensors. The model is expected to help students in understanding the concepts of physics through experiments using smartphone sensors.

Keywords: model, physics experiment, smartphone sensor

Introduction

Verkasalo, et al. (2010) reported that not all smartphone users maximize the sensor functions found on smartphones. Users only access simple applications related to daily communication and do not involve all sensors. The use of smartphones in physics experiments was first carried out by Müller, et al. (2010) in a smartphone sound experiment on air vacuum tubes, followed by subsequent studies (Voght and Kuhn, 2012, 2013). The two papers triggered subsequent studies on the use of smartphones. Experiments using smartphone sensors are divided into four categories, as follows.

First, research uses sensor hardware installed in the smartphone to obtain certain data. The data are then illustrated in a graphical form for subsequent analysis (Müller, et al., 2010; Voght and Kuhn, 2012, 2013; Taspika, et al., 2018; Klein, et al., 2014; Kuhn and Voght, 2013). Second, research uses certain Android or iPhone applications that are installed on smartphones. The application can record data while displaying data plotting directly on the smartphone screen (Chevrier, et al., 2013; Oprea and Miron, 2014; Forinash and Wisman, 2012; Sans, et al., 2013; Staacks, et al.). Third, research uses cameras and screens on smartphones in which the ability of digital cameras on smartphones can record the movements of objects in physics experiments, so that physical symptoms can be observed (Tornaria, Monteiro, and Marti, 2014). Fourth, physics research combines sensors, cameras, and screens on smartphones with other data such as GPS data, Earth's magnetic pole and other data (Science on Stage, 2021).

The smartphone is affordable and can be bought easily anywhere so students and teachers can use it in physics experiments at school. It is, therefore, necessary to develop a manual for using standard smartphones for physics experiments at school. The teachers and students can gain benefits from it.

Methods

Mobile phones have at least two transducers or sensors namely sound and signal sensors. As the development of smartphone technology is very rapid, the number of sensors used also increases. The latest smartphones have at least 11-12 sensors embedded in the device. The more sophisticated the smartphone specifications, the more sensors are installed in the smartphone.

Figure 1. Number of sensors on a Smartphone (Majumder and Deen, 2019)

As a guide for data retrieval in a physics experiment, teachers must provide physics experiment manuals. The manual can be arranged based on textbooks or other references.

Conventional physics experiments can be arranged based on a diagram shown in Figure 2. Physics experiments based on this diagram fully use physics tools from the laboratory. For physics experiments using smartphone sensors, the manual diagram in Figure 2 must be modified so that it contains steps of identifying sensors within the smartphone that will be used for experiments and calibrating them (Figure 3).

Figure 2. Physics experiment diagram

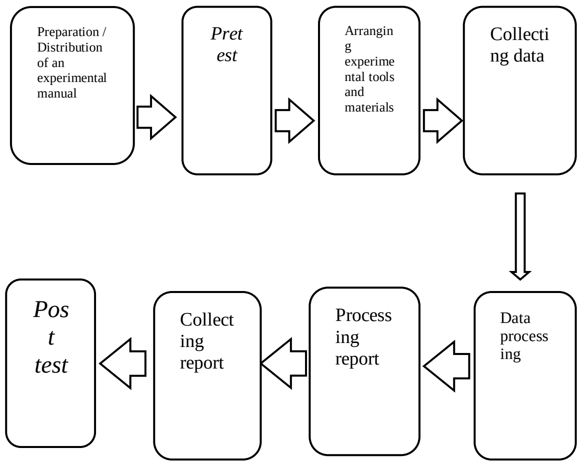
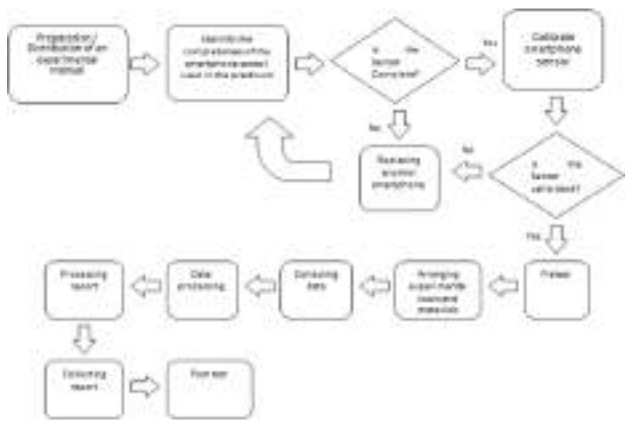


Figure 3. Diagram of physics experiment using smartphone sensor



The study was carried out by testing two types of laboratory manuals on students: the first laboratory manual for ordinary physics labs and the second for the laboratory manual physics involving smartphone sensors.

The level of success and understanding of students can be compared in the two types of laboratory manuals.

The study took data from several sensors on smartphones that were used in two physics experiments. The topics of the experiments were chosen based on the ease of data retrieval using sensors and the order of delivery of material in class. The following topics of the experiments:

a. Oscillatory motion of a pendulum

In this experiment, we use a gyroscope sensor and an accelerometer as the motion sensor. The smartphone is taken as the bob of the pendulum with varied strings. Moving back and forth of the smartphone show the oscillation. Data that appears in the sensor are in the form of changes in the coordinates of the smartphone's position. By using the Phypox pendulum period application, the students see the sinusoidal graphs of the oscillatory motion.

b. Free fall motion (acceleration due to gravity)

We consider objects that experience a free fall motion with a zero initial velocity and a certain height above the Earth's surface. The objects experience a constant gravitational acceleration. The value of gravitational acceleration can be calculated from the travel time of the object during the motion. The microphone sensor on the smartphone can be used to capture sound waves that appear during the objects falling. The time interval of the sound waves is then recorded.

The most important thing in a manual experiment is the instructions for using the application/software used when retrieving data. In this study, the android application used was PHYPHOX developed by RWTH Aachen (Staacks, et al., 2018). This application has several advantages. Students can see graphs of data recorded from the sensor directly on the laptop screen using a wifi hotspot on the condition that the smartphone and laptop are connected to the wifi network. Visible data can be downloaded in the form of graphs or numerical data so students can process and study the data.

A physics experiment guide compiled by the teacher as a researcher is applied in the classroom by students to retrieve data. Experiment guides must be in a standard format, containing information on the specifications of the smartphone used, types of applications, materials, and practical tools as well as the experimental procedures.

The testing of experimental instructions is carried out in two stages according to the number of experiment titles. Before testing students should first read the practical instructions and install the required applications. Data collection for each experiment's title requires 30-35 students.

Results and Discussion

Before starting an experiment using smartphone sensors, students are required to check the availability of sensors on their smartphones and calibrate the sensors that will be applied for the experiment. The existence of sensors in a smartphone can be traced from smartphone specifications or also by installing a certain application that can detect all the sensors. Sensor calibration can be done by installing an application that can calibrate the sensors installed in the smartphone. Some smartphones have facilities embedded in each smartphone that can calibrate a sensor by itself.

The application of Physics sensor-based experiments smartphone methods can be seen from the level of understanding of students. Likewise with the effective use of these methods in physics experiments. To test the level of students' understanding can use the pretest-posttest during physics experiments. This test is also known as the before-after method. The test results using the question instrument show an increase in students' understanding. If using conventional experiments methods the level of understanding achieved is 46%, whereas if using a smartphone sensor-based physics experiments method the student's understanding level becomes 92%.

In addition to the level of understanding of students, we also study the effectiveness of the use of smartphone sensor-based physics experiments methods. Testing uses paired t-test-related methods. The components tested in these experiments are the components contained in the experiment instructions. These components are:

a. Aim

b. Basic theory

c. Tools and Materials

d. Procedure

e. Data retrieval

f. Data processing

g. Graphical depiction

h. Conclusions.

The data analysis shows a significant increase in the level of ease of using smartphone sensor-based practical methods. In conventional physics experiment methods, student respondents showed an average level of ease of 54%. This shows that students have difficulty understanding conventional physics experiment instructions. On the other hand, the results of data analysis on smartphone sensor-based physics experiments showed an average yield of 91%, a 37% greater than the previous method. The calculation of the paired-related t-test obtained a difference value of -11.94, the value of P = 0.00, with group 1 mean (conventional experiment instructions) being 17.21 and group 2 mean (sensor-based experiment instructions) being 29.15. So data analysis is significant and tends to increase. Experiments using a smartphone can be better carried out provided that all the smartphones used by students should be the same type and brand. Accordingly,

1. Students should have the same type and brand of smartphone, or

2. The school provides several smartphones of the same type and brand.

Conclusion

A smartphone sensor-based physics experiment can be carried out by considering the unavailability of measuring instruments and the efficiency of the experiment's data processing or graphical depiction. Physics experiments that are carried out must be integrated with sensors embedded in smartphones. Applications used on smartphones consider the ability of these applications to read data from sensors and the number of sensors available on smartphones.

The principle of using a smartphone sensor in physics experiments is that the sensor can read changes in physical symptoms to be observed. Examples of changes in physics are changes in position, changes in sound frequency, orientation changes and so on. Experiments can be carried out by considering the completeness of the sensor and the suitability of the application with the smartphone.

Experiments instructions as a guide for students in implementing smartphone-based physics experiments are prepared by the teacher by adding the following elements:

a) Sensor type

b) Operating system (Operation System / OS) from a smartphone

c) Sensor calibration warning

d) Types of smartphone applications

e) Instructions for use of the application

After carrying out and analyzing the research data, the following recommendations are generated:

1) Testing methods on other smart devices such as smartwatches and smart bands.

Development of more smartphone-based physics experiments.

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2022

SciEd
SEAQIS Journal of Science Education

SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 2, No: 1, PP: 39-50
www.journal.qitepinscience.org

Research Paper | Open Access

Challenges in Inquiry-Based Science Learning in Online Distance Learning Modality: Input to Action Plan

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Abstract

The K-to-12 science curriculum promotes the use of Inquiry-Based Science Learning (IBSL) as a pedagogy to achieve scientific literacy. However, the COVID-19 pandemic has disrupted the conventional education approach in migration to new normal. This sequential explanatory research was conducted to explore the students' challenges encountered in IBSL in Online Distance Learning Modality (ODLM) at a public integrated high school. Stratified random sampling was used to select the 261 students as respondents from Grades 7 to 12. Researchers-developed survey questionnaires was administered online. Descriptive statistics was employed to analyse the collected data. Results revealed that majority of the students encountered not much challenges in learning resources, competence to technology tools, online self-efficacy, teachers' pedagogy, motivation, and support system. However, specific indicators received higher mean, implying that certain challenges still existed. To further explore such challenges, in-depth interview was conducted among 12 purposively selected participants. Thematic analysis was utilised to interpret the data. Results disclosed other domains of challenges. Some students experienced limited interaction and received minimal assistance among peers. Meanwhile, lack of constant communication impeded continuous science learning. Fundamental science topics were not rigorously discussed, while the absence of experiments resulted to poor laboratory skills. Furthermore, online science pedagogies were not fully utilised. Challenges are evident; hence, these findings provide pedagogical insights to enhance the use of IBSL in new learning modality. An action plan is hereby proposed to reduce the challenges in IBSL in ODLM.

Keywords: challenges; inquiry-based science learning; online distance learning modality; sequential explanatory research

Introduction

The COVID-19 pandemic has changed the conventional teaching and learning practices of schools adopting the emergency remote education (Ancheta & Ancheta, 2020). This abrupt shift (Tria, 2020) has set off changes evident in the operationalisation of the Basic Education Learning Continuity Plan (BE-LCP) of the Department of Education (DepEd) in which alternative learning delivery modalities are implemented (Hernando-Malipot, 2020). One of which is the Online Distance Learning Modality (ODLM) which is the most preferred learning modality in schools as it provides a platform to conduct live interaction and student engagement using online educational resources, platforms, and tools accessed through the internet (DepEd, 2020; Bartlett & Warren, 2021).

Science education provides a crucial role to succeed in today's global knowledge environment (Sunga & Hermosisima, 2016). The science curriculum of the K to 12 program aims to develop scientific literacy which serves as a measure of success evident in students' learning gains and achievements (Codon & Polong 2020). Hence, the K to 12 curriculum highlights the use of pedagogical approaches such as Inquiry-Based Science Learning (IBSL) which provides learners the opportunities to investigate a problem, ask questions, test out ideas, seek for possible solutions, make observations, and manifest creative thinking (DepEd, 2019). This pedagogical approach supports good science teaching and active learning (Constantinuo et al., 2018) that promotes students' engagement, interest, and motivation. Previous studies revealed that IBSL created better learning opportunities (Chu et al., 2017), enhanced critical thinking (Destino & Cunningham, 2020), as well as improved conceptual understanding, 21st-century skills, and learning attitude of students (Abaniel, 2021).

Despite its beneficial implications, challenges have surfaced as teachers are confronted with complexities (Koyunlu Unlu & Dokme, 2020) in preparation, planning, and execution. This is further compounded by prevalent issues in science education (Sadera et al., 2020) including scarcity of science teachers, lack of motivation and interest among learners, low self-assurance in learning science, absence of science laboratories and facilities, congested curriculum, and poor quality of learning resources. Furthermore, the COVID-19 pandemic enlarged the situation on how to deliver IBSL in ODLM. The instant adoption of online teaching (Hodges et al., 2020) results to lack of creativity, resourcefulness, and innovation (Doucet et al., 2020) leading to difficulties and complexities in instructional delivery and assessment. As a result, students reported poor interpersonal connection (Driver, 2018), absence of sense of community (Reedy, 2019), and lack of motivation (Manalo et al., 2022). Science should be learned as a way of inquiry; however, by blending the teaching strategy with ODLM can hampers its success without adequate skills as well as rigorous ICT training and resources (De Villa & Manalo, 2020).

This situation has led the researchers to explore the challenges encountered by learners in IBSL in ODLM to provide a platform for science teachers which inform about the students' issues and concerns to create intervention programmes and sustain quality science teaching and learning amidst the emergency remote education.

Objectives of The Study

This study attempts to explore the students' perceived challenges in IBSL in ODLM, specifically to answers the following queries:

1. What are the students' perceived challenges in IBSL in ODLM as to:
   1.1. learning resources,
   1.2. competence to technology tools,
   1.3. online self-efficacy,
   1.4. teachers' pedagogy,
   1.5. motivation, and
   1.6. support system?
2. What are the students' lived experiences in IBSL in ODLM?

What action plan may be proposed to minimise students' challenges in IBSL in ODLM?

Methodology

The study employed sequential explanatory design, a type of mixed method research which starts with the collection and analysis of quantitative data followed by qualitative data (Creswell & Creswell, 2017). For the quantitative phase, a total of 261 students from junior and senior high school programmes at San Pablo City Science Integrated High School were randomly selected in strata as respondents. A researcher-developed questionnaire called "*Challenges in IBSL in ODLM Questionnaire*" was used as the main instrument. This underwent expert validation and reliability test. The survey questionnaires encoded in Google Forms were administered among the respondents online. Descriptive statistics such as mean and standard deviation were computed to analyse the students' responses. For the qualitative phase, 12 participants were purposively selected for in-depth interviews that were conducted via online platforms. Thematic analysis was used to analyse the participants' responses.

Results and Discussion

Students' Perceived Challenges in IBL ODLM

Table 1. *Perceived Challenges in IBSL as to Learning Resources*

Indicators	Mean	SD	Remarks
1. Digital and/or printed copies of learning modules	1.41	0.75	Not at all
2. Supplementary materials	1.54	0.88	Not much
3. Stable internet connection	1.28	0.53	Not at all
4. Support devices or equipment	1.19	0.49	Not at all
5. Access to online libraries	1.50	0.80	Not much
6. Access to online simulation and virtual laboratory sites	1.73	0.86	Not much

Learning resources supported student learning. This has become even more critical nowadays while remote learning was implemented (Reimers et al., 2020). Results showed that learners were equipped with necessary resources used in ODLM. Internet connectivity, devices, and digital modules were available. However, indicator 6 received the highest mean perception which concerned on learners' access to online simulations and virtual laboratories.

Authentic science learning was attained through experiments and investigations. However, it has become more challenging to conduct laboratory work during remote learning (Gamage et al., 2021). Moreover, indicator 5 also obtained a high mean perception. Online libraries have become the learners' study partners to get credible information in ODLM (Zhou, 2021), but limited access may hinder students' drive to learn.

Table 2. *Perceived Challenges in IBSL as to Competence to Technology Tools*

Indicators	Mean	SD	Remarks
1. Videoconferencing applications	1.50	0.72	Not much
2. Virtual classroom	1.36	0.58	Not at all
3. Office productivity tools	1.60	0.77	Not much
4. Social media	1.38	0.67	Not at all
5. Online collaboration tools	1.33	0.61	Not at all
6. Messaging tools	1.28	0.55	Not at all
7. Video sharing sites	1.34	0.61	Not at all
8. Online simulation and virtual laboratory	2.27	1.04	Not much
9. Video and image editing tools	1.71	0.89	Not much

Educational technology tools have made learning become more accessible, simpler, and less laborious (Bala, 2020). Results revealed that majority of the students were competent in using technology tools. Websites, e-programs, and online applications were necessary in ODLM. However, indicator 8 revealed that there were learners who struggled in using online simulations and virtual laboratories. This was parallel to the significant findings in Table 1 in which access to online simulations and virtual laboratories has become a challenge too. Science teachers should also empower learners to develop their competencies in operating technology tools.

Table 3. *Perceived Challenges in IBSL as to Online Self-Efficacy*

Indicators	Mean	SD	Remarks
1. Fixing technical problems and issues	1.87	0.76	Not much
2. Using new type of technology easily and efficiently.	1.54	0.70	Not much
3. Learning well in an online learning environment.	2.07	0.98	Not much
4. Managing time effectively during online learning.	2.20	0.98	Not much
5. Completing online tasks on time	1.69	0.89	Not much
6. Seeking online materials and resources in the web	1.67	0.76	Not much
7. Searching information online	1.45	0.69	Not at all
8. Using synchronous and asynchronous technologies efficiently	1.73	0.85	Not much
9. Using online messaging tools and/or social media platforms for easy communication	1.63	0.79	Not much
10. Accomplishing individual tasks and/or group projects online.	1.75	0.82	Not much

Self-efficacy was a crucial component of students' skills in ODLM (Yavuzalp & Bahcivan, 2019) since they were expected to take responsibility of their own learning. Results uncovered that majority of the learners had high level of online self-efficacy. This implied that students could utilise technology effectively. Learners are adaptable to online platforms and digital tools since they are part of Gen Z who are called digital natives.

Yet, some students were not at ease learning in an online environment and could not manage their time effectively as shown in indicators 3 and 4 respectively. There were a lot of distractions in ODLM since house and school boundaries became unclear. As a result, this may interrupt learning goals among students. Therefore, they need to improve their time management skills to finish the tasks ahead of time so that they can still enjoy their leisure time (Joubert, 2020).

Table 4. *Perceived Challenges in IBSL as to Teacher's Pedagogy*

Indicators	Mean	SD	Remarks
1. Giving self-paced activities	1.47	0.66	Not at all
2. Encouraging questions and discussions	1.20	0.53	Not at all
3. Providing guided activities	1.38	0.58	Not at all
4. Providing collaborative tasks	1.33	0.59	Not at all
5. Using online simulation and virtual laboratory activities	1.98	0.92	Not much
6. Exploring different facets of online learning environment.	1.40	0.61	Not at all
7. Contextualizing lessons	1.46	0.65	Not at all
8. Providing personalized activities	1.56	0.80	Not much

9. Using different assessment methods.	1.53	0.71	Not much
10. Providing feedbacks	1.68	0.84	Not much

Distance learning does not guarantee the complete adoption of teaching strategies that are routinely utilised in face-to-face classes (De Villa & Manalo, 2020). Hence, teachers continue to reinvent their pedagogical goals which are appropriate to ODLM by utilising relevant online tools (Calixto et al., 2021). Science teachers allow students to enjoy online learning opportunities through active participation in class discussions, raising questions, provision of self-paced, as well as guide individual and group tasks. Lessons and activities are personalised and contextualised, while assessment methods are varied. However, as shown in indicator 5, it appeared that some students believed that their science teachers employed limited online simulations and virtual laboratories. This can be attributed to teachers' lack of resources and skills due to the abrupt shift of learning modalities. Moreover, indicator 10 revealed that some students agreed that teachers' provision of feedback served as a challenge. The demands for teachers' presence are raised during ODLM in which they are expected to always present and give quicker responses. Providing immediate feedback assists learners to bridge the gap between where they are and where they need to go (Hattie et al., 2021).

Table 5. *Perceived Challenges in IBSL as to Motivation*

Indicators	Mean	SD	Remarks
1. Interest in learning science concepts	2.23	1.11	Not much
2. Drive to accomplish science activities	1.97	0.98	Not much
3. Individual accountability in self-paced activities	1.97	0.92	Not much
4. Enjoyment in group tasks	1.78	0.90	Not much
5. Enthusiasm in learning science	1.92	1.01	Not much
6. Persistence to finish science tasks on time	1.54	0.78	Not much
7. Willingness to perform better	1.52	0.77	Not much

Motivation reassures learners to be more engaged in science learning. Their drive, interest, enjoyment, persistence, and willingness to learn are set by motivation. Results showed that majority of the students were motivated to learn despite the change of learning modalities. However, it could be gleaned that indicator 1 received the highest mean perception which implied that some of them tended to lose interest to learn science in ODLM. This may be attributed to the lack of hands-on activities, experiments, and investigative projects which were considered as the keys of science learning to maintain their motivation and engagement (Manalo, 2021) by considering learners' contexts such as their personality, situations at home, and fondness.

Table 6. *Perceived Challenges in IBSL as to Support System*

Indicators	Mean	SD	Remarks
1. Monitoring, counselling, and remediation	1.50	0.73	Not much
2. Using technology tools and online platforms	1.47	0.69	Not at all
3. Learning resources	1.18	0.47	Not at all
4. Conducive learning space at home	1.44	0.74	Not at all
5. Assistance during science activities.	1.44	0.73	Not at all
6. Help in doing challenging tasks	1.47	0.76	Not at all
7. Support in mental and emotional struggles	1.90	1.06	Not much

Support system is a critical component of students' learning so that they are able to cope with academic and personal demands of remote learning (Shikulo & Lekhetho, 2020). Results revealed that majority of the students received the support they need in terms of the provision of resources and learning space, accomplishing tasks, using unfamiliar tools, and supervision. However, indicator 7 obtained the highest mean perception. This implied that some students received minimal support in coping with mental and emotional problems. Anxiety and stress are evident among learners' experiences in remote learning (Watermeyer et al., 2020) due to isolation, no boundaries between home and school, fear of the pandemic, etc. Hence, the situation calls for more compassion, empathy, and positive well-being support from family and school. Considerations, kindness, patience, and understanding should be given among learners to alleviate adverse feelings (Calixto et al., 2021).

Students' Lived Experiences in IBSL in ODLM

Theme 1. Limited interaction among peers during collaborative tasks

Collaboration is a crucial skill in IBSL. Learners collaboratively work with their peers through engaging activities which allow them to manifest cooperation, listen to others' views, and being open-minded (Korkman & Metin, 2021). A sense of community among students can satisfy leaners' overall online learning experiences (Fuller et al., 2015). However, the results revealed that some learners could not fully collaborate with their peers during online science activities. It has become challenging to communicate with peers instantly during group activities, hence, resulting to lack of interest and vitality to accomplish the task. They just tended to divide the tasks without genuine teamwork in discussing the pieces of information contributed by each learner. Some tasks are complicated, but learners cannot easily get to work with their classmates due to poor internet signals, conflicts in schedules, and varied issues at home. Lack of communication, hence, impede continuous science learning among students. This case has lost their motivation to learn in groups and tended to learn independently instead.

Theme 2. Fundamental science topics were not rigorously discussed

DepEd has released the Most Essential Learning Competencies (MELCs) in order to focus on teaching and learning the most relevant topics that the learners must acquire, thus, developing them into life-long learners (Gonzales, 2020). These competencies were fit in the provided number of days per quarter in accordance with the suggested Budget of Work (BOW). However, the results revealed that students faced difficulty in understanding some of the science lessons provided during online classes. Since lessons were fixed already to conform with the indicated number of days, there were still requisite topics which were not rigorously discussed. Furthermore, teachers and students only met two hours per week during synchronous sessions. The rest of the hours are allotted to asynchronous sessions in which video lessons and activities are given. Hence, it has become difficult for teachers to unpack the competencies. This resulted to more problems such as less mastery of the foundational concepts which served as building blocks of higher science skills.

Theme 3. Absence of hands-on experiments resulted to poor laboratory skills

Hands-on experiments provide students the opportunity to acquire practical and manipulative skills as well as learn experimental techniques. These are essential to obtain science process skills which are the foundations of quality science learning. However, students uncovered that its absence made their science learning experiences inadequate. They just knew the theoretical concepts but lack of practical applications. However, previous studies mentioned that the online laboratory experience was the same as or better than the conventional approach since such was convenient, accessible, and stress-free (Rowe et al., 2018). However, this was not the case, as students mentioned that teachers utilised limited online simulation and virtual laboratory. Thus, the students received only minimal online science experiences. Individualised instruction and access to laboratory education had been compromised causing adverse impacts on student engagement in scientific experimentation (Achuthan et al., 2021).

Theme 4. Online science pedagogies were not fully utilized

Live interaction among teachers and students and the learning resources have become widely accessible and available (Yang, 2013). However, the results showed that some students found that it was difficult to learn science topics in ODLM. They attributed it to science teachers' practices and methods used in online classes. Video lessons and reading materials were just sent in the virtual classroom. Though recitation was still evident, most of the time, lecture method was employed. However, teachers could not be blamed since the emergency of online migration was unprecedented. Only little had been done to develop effective instructional strategies for online classes (Akdemir, 2010). Hence, teachers found it difficult to teach topics which require hands-on activities and live demonstrations. With limited knowledge and skills on facilitating online instruction, teachers embraced the modality even without adequate training.

Proposed Action Plan

Project, Program or Activity	Objective	Duration and Persons Involved	Success Indicators
Creating contextualised and localised learning resources	To create contextualised and localised science learning materials to be used in ODLM	Quarterly Subject coordinator Science teachers Validators	100% of science teachers produced science learning materials for distribution among learners
Learning Action Cell (LAC) sessions on digital learning	To conduct training sessions to enhance teachers' and students' on utilizing educational technology tools and improving online self-efficacy	Monthly Resource speaker Science teachers Students	100% of the science teachers and students improved their digital skills
Capacity building program for science teachers' pedagogical content knowledge	To enhance science teachers' pedagogical content knowledge in employing IBSL in ODLM	Quarterly Resource speaker Science teachers	100% of the science teachers enhanced their pedagogical content knowledge in using IBSL in ODM
Kumustahan: A psycho-social support	To provide a psycho-social support for students'	Quarterly	100% of the students were guided accordingly as to

program for students	mental and emotional concerns	Guidance counsellor School head Science teachers Students and their parents	psycho-social support needed.
	To help students elevate their motivation and engagement amidst emergency remote education		100% of the students were highly motivated and engaged in science learning.
Stakeholders' Power-up: Strengthening support and linkage	To provide a stronger support system in students' educational undertaking in emergency remote education	All-year round School stakeholders (internal and external)	100% of the target stakeholders provide support in various capacities to address students' needs in science learning.

Conclusions

Based on the findings of the study, the following conclusion are derived.

1. The implementation of ODLM amidst COVID-19 pandemic poses challenges in IBSL. However, minimal challenges are experienced by most learners in terms of learning resources, competence to technology tools, online self-efficacy, teachers' pedagogy, motivation, and support system. Moreover, certain challenges still exist as revealed by specific indicators.
2. Challenges are still bound to exist as IBSL is drastically implemented in a different learning modality such as ODLM. Limited class interaction, minimal assistance from peers, lack of communication, limited discussion of fundamental science topics, absence of experiments, and inadequate online science pedagogies are the challenges experienced by the learners.
3. ODLM has been the most preferred modality during remote learning. Despite its benefits and opportunities, challenges are manifested. Hence, the proposed action can be looked into, considered, and implemented to help science teachers in sustaining IBSL in ODLM amidst the emergency remote education.

Recommendations

The following recommendations are stated for future considerations.

1. Training programs on the use of IBSL in ODLM may be developed based on the domains of challenges. This may help to minimise the challenges faced by learners as well as teachers.
2. Challenges may be revisited in order to create plans of action. This may serve as relevant inputs to enhance the implementation of the schools' BE-LCP particularly in teachers' upskilling and reskilling and improvement of learning environment.

Similar research studies may be conducted to examine other domains of challenges amidst the student diversity and different learning modalities.

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ISSN 2964-7533
ISSN 2987-8101

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