SciEd

SEAQIS Journal of Science Education

SciEd Journal / vol. 1 / no. 2 / 2021
P-ISSN 2777-0397
E-ISSN 2798-7175
www.journal.qitepinscience.org

SciEd

SEAQIS Journal of Science Education

Table of Contents

SEAQIS Journal of Science Education (SciEd)

Volume 1 | No 2 | December 2021
P-ISSN 2777-0397 | E-ISSN 2798-7175

The Desk

SEAQIS Journal of Science Education (SciEd)

Volume 1 | No 2 | December 2021

P-ISSN 2777-0397 | E-ISSN 2798-7175

SEAQIS Journal of Science Education (SciEd), The Southeast Asian Journal of Science Education, is a scientific publication of SEAMEO QITEP in Science published once 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:

Training course on Computational Thinking was developed in line with the acceleration of digital transformation that supports the mastery of 21st century skills. One of the skills needed in the future is the ability to solve problems effectively and efficiently.

2021
SciEd
SEAQIS Journal of Science Education
SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 1, No: 2, PP:1-17
www.journal.qitepinscience.org
Research Paper
Open Accsess

Through the teacher's lens: Evaluation of the project-based curricula of Philippine and Japanese science high schools

Leo Peter Dacumos[1,2] and Masakazu Kita[2]

[1]*Philippine Science High School – CAR Campus, Philippines.*
[2]*Graduate School of Education, Okayama University, Japan*

Abstract

Specialized science, technology, engineering, and mathematics (STEM) high schools provide intensive learning experiences for advanced learners. At the core of these STEM, schools are a project-based (research) curriculum that aims to foster research culture among learners, creating critical thinkers and problem-solvers, preparing them to be globally competitive STEM professionals in the future. The Philippine STEM junior high school's system and Japan's Super Science High (SSH) are amongst implementers of the project-based (research) curricula. Hence, this paper sought to conduct a critical review of these project-based curricula through quantitative analysis of Filipino and Japanese teachers' perceptions of its effectiveness along the four dimensions of Tyler's Objective-centred Model for curricular evaluation. Findings show similarities and significant differences in the perception of the project-based curricula' effectiveness between Filipino and Japanese teachers along the four dimensions of Tyler's Objective-centred Model: (1) learning objectives; (2) learning experiences; (3) organization of learning experiences; and (4) evaluation methods.

Keywords: Project-based Curriculum, Research, STEM, SSH.

Introduction

While STEM-focused specialized schools are of today's research interest, the existence of such schools has been recorded for over 100 years. Specialized secondary schools were established in response to economic, political, and educational currents (Thomas & Williams, 2010). Most particularly after World War II, the United States began instituting specialized science high schools to foster future scientists' and engineers' development. Specialized science, mathematics, and technology-focused high schools offer intensive education for developing science talent at the secondary level (Kettler & Puryear, 2018). These schools provide advanced learning experiences for gifted and advanced students by offering advanced curricula that emphasize a higher understanding of the sciences and mathematics. Kettler and Puryear (2018) further claimed that specialized schools for science and mathematics include students' engagement in research or project-based studies who are guided by "faculty members who are experts in content and research methodologies". Engagement in project-based studies or research of students and mentorship of faculty are "two of the most distinctive features that separate specialized high schools from tradition high school programs for gifted and talented science and mathematics students".

Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT) adopted the "Science Literacy Enhancement Initiatives" in 2002 to implement comprehensive policies to support and promote science and technology education with a focus on project-based study activities. One of the main contents of this plan is to designate schools that prioritize science, technology, and mathematics education as "Super Science High (SSH) Schools," and research and develop policies for education courses placing importance on science and mathematics and for active cooperation with universities and research institutions.

In 2002, the first year of its operation, 26 schools were awarded the SSH status. In 2007, 101 schools were designated. As of 2020, 178 schools were awarded such designation, committed to being involved in developing science and technology education, including research and development amongst students in Japan (Japan Science and Technology Agency, 2017). These schools received governmental subsidies to prepare equipment, materials, and consumables required for students to conduct experiments in pursuit of research and development. Furthermore, designated super science high school programs can conduct their original experimental curriculum without being bound by national curricula (Science and Technology System Reform, 2008). Hence, various schools in Japan with SSH designations are free to make their unique curricula, particularly in the implementation of research classes.

On the other hand, cognizant of the need to also strengthen science and mathematics education in the country, the Philippine government has started several programs in basic education, particularly at the secondary level. Thus, the creation of the Science, Technology, Engineering, and Mathematics Education Program (STEM, formerly Engineering and Science Education Program or ESEP). The STEM program is a science and mathematics-oriented curriculum devised for high schools in the Philippines. Supervised by the Department of Education, specialized high schools offer the STEM program. Currently, more than 150 high schools are offering the STEM program, the majority being public. It was piloted in 1994 by the Department of Education, Culture and Sports (now DepEd) in collaboration with the Department of Science & Technology (DOST).

Currently, the Philippines STEM high school system is generally categorized into STEM high schools, Regional Science High Schools, and Philippine Science High Schools (PSHS) which offer curricula placing importance in mathematics, sciences, and research (project-based study). STEM high schools and regional science high schools are operated by DepEd, while the DOST operates the PSHS system. Collectively, these schools are formulated with the aim of not only putting importance on science and mathematics curricula but also improving science and mathematics research amongst students in basic education. The governmental subsidy was allotted for student science project-based studies, specifically in the form of support to the conduct of science and mathematics investigatory projects such as payment for laboratory analysis, supplies, rentals of equipment, spaces, and transport (DepEd Order No. 55 s. 2010 & DepEd Order No. 15 s. 2014).

Country-wide implemented curriculum in STEM high schools in the Philippines started with enriched science, mathematics, and English curriculum in addition to the standard requirements of the new secondary education curriculum (DECS Order No. 69 s. 1993). However, research opportunities were then limited to the third year (Research in Biology) and fourth year (Research in Physics) putting lesser emphasis on other scientific and mathematical fields. The program failed to provide novice student researchers enough time to follow the rigour of research writing having only two years to finish biology and physics research, respectively.

A revision was made with the release of DepEd Order No. 41, s. 2004, in which Research 1 (Basic Statistics in Research) is offered to second-year students and Research

2 (Research in Science) which tried to shift the former biology-physics dichotomy of research in high school to a more science-inclusive research course. Again, with this revision, another problem arose, that is, while statistics have been an essential concept in doing research, researching proper was limited to one academic year for students who are beginners in conducting research. Having limited time allotment for research conceptualization, research plan presentation, partnership with external institutions and laboratory, experimentation, and final research presentation, had become a struggle not only for inexperienced students but also for the facilitation of the teachers.

The two earlier project-based (research) curricula failed to provide the students enough time to follow the rigorous processes of doing research. Hence, in 2014, a significant facelift of research curriculum was proposed alongside the adoption of the current K to 12 basic education programmes of the Department of Education, which increase the number of years for basic education, i.e. addition of two years in high school which was separately called as Senior High School. The proposed science and technology-oriented high schools (STEM high schools) academic program this time includes research courses I to IV distributed across the four-year levels of the junior high schools (K to 12 special science program project-based (research) curriculum guide, 2014): Research I (Scientific Attitudes, Science Process Skills, and Basics of Scientific Method) for grade 7, Research II (Research Plan preparation) for grade 8, Research III (Experimentation and Data Collection) for grade 9, and Research IV (Improvement and Development of New Research and Research Presentation) for grade 10.

Curriculum evaluation is a vital aspect of any education system. This process provides a basis for curriculum policymaking and feedback for curriculum modifications and implementation (Wang, Wang & Meng, 2016). Guba and Lincoln (1981) suggested putting importance on the aspects of merit (intrinsic value of the curriculum), and worth ("payoff" value of the curriculum) when evaluating curriculum. In other words, merit is an assessment of the content, programs, activities, and learning opportunities provided by the curriculum while worth assessment is its value in a specific application (Curriculum Evaluation, n.d.).

Now, this leads to the question, how can the merit and worth of such aspects of the curriculum be determined? One of the most popular models for curriculum evaluation is that of Ralph Tyler's (1950) Objectives-centred Model. Tyler's model evaluates the degree to which curriculum goals or objectives were achieved. Anh (2018) citing Popham (1995) discusses that the model mainly involves the "careful formulation according to three educational goals (the student, the society, and the subject matter) and two-goal screen (a psychology of learning and a philosophy of education)" (p.25).

Tyler (1976) discusses the four major dimensions or steps of curriculum evaluation: 1. Selecting educational purposes; 2. Selecting learning experiences; 3. Organizing learning experiences; and 4. Evaluation. These four dimensions should answer the following questions: *"What should the educational objectives of the curriculum be? What learning experiences should be developed to enable students to achieve the objectives? How should the learning experiences be organized to increase their cumulative effect? How should the effectiveness of the curriculum be evaluated?"*(p.42).

In the context of the current study, curriculum evaluation using the Tylerian Objective-centred model was used to compare the implementations of the project-based (research) curricula of Japan's Amaki Senior High School (Super Science High School) and Philippines Department of Education's Science, Technology, and Engineering (STEM) Program along four dimensions enumerated by Tyler.

This study aimed to compare the curriculum implementation of Japan's Super Science High School (SSH) and Philippines' Science, Technology, Engineering, and Mathematics (STEM) Program against the four dimensions of Tyler's Objective-centred model. Specifically, this study sought to answer the following question: What is the extent of effectiveness of the project-based (research) curriculum along the following dimensions as perceived by the teachers?

a. formulated learning objectives of the project-based (research) curriculum;
b. identified learning experiences in the curriculum to enable achievement of objectives;
c. organization approaches of learning experiences; and

evaluation methods of the project-based (research) curriculum

Methods: Research Design

This research utilized a descriptive comparative research design. The quantitative approach involved the use of a survey questionnaire measuring the extent of effectiveness of the identified curricular learning objectives, learning experiences, organization approaches, and evaluation methods of the project-based (research) curricula of the two STEM high school systems. These were assessed by teachers from both systems who are involved in the implementation of the project-based (research) curriculum.

Participants and Documents

Select teachers from Super Science High Schools in Okayama, Japan (n=23) and DepEd's STEM High Schools (n=35), who are involved in the implementation of the project-based (research) curriculum, answered a survey questionnaire measuring the extent of effectiveness along the following dimensions based on Tyler's Objective-centred model: *identified curricular learning objectives*, *learning experiences, organization approaches, and evaluation methods* of the research curricula of the two STEM high school systems. The profile of teachers are as follows:

Table 1.0 Distribution of teachers from select science junior high schools and super high schools in the Philippines and Japan

Country	School	Number of Participants
Japan (23)	Tsuyama High School岡山県立津山高等学校	5
	Ichinomiya High School岡山県立岡山一宮高等学校	5
	Kurashiki Amaki High School岡山県立倉敷天城高等学校	13
Philippines (35)	Baguio City National Science High School	5
	Bautista National High School	1
	Benigno V. Aldana National High School	2
	Bukidnon National High School	1
	Canan National High School	1
	Candaping National High School	1
	Don Ramon E. Costales Memorial National High School	3
	Guihulngan National High School-Poblacion	1
	Juan G. Macaraeg National High School	1
	Luna National High School	1
	Manaoag National High School	1
	Mataas na Paaralang Neptali A. Gonzales	1
	Marcelo H. del Pilar National High School	1
	Ozamiz City National High School	1

Puerto Princesa National Science High School	1
Quezon City Science High School	3
Sablayan National Comprehensive High School	1
San Fabian National High School	1
San Jacinto National High School	1
Manila Science High School	1
Tagbina National High School	1
Tarlac Montessori School	1
Tayug National High School	3
Valenzuela City School of Mathematics and Science	1

Data Gathering Instrument and Procedure

Teachers were asked to answer a 21-item questionnaire. The questionnaire used in this research consisted of carefully written subdimensions providing a comprehensive description of the four dimensions of Tyler's Objective-centred model. The subdimensions included are as follows: *self-sufficiency, comprehensiveness, validity, interest, significance, utility, learnability, and feasibility* for the identified curricular learning objectives; *validity, comprehensiveness, variety, interest, relevance to life, and suitability* for the learning experiences; *continuity, sequence, and integration* for organization approaches; and *variety, effectiveness, validity, and comprehensiveness* for evaluation methods. The domains, subdimensions, and their descriptors were written in both English and Japanese for the Filipino and Japanese teachers, respectively. Each subdimension is rated according to the extent of its effectiveness in the context of the project-based (research) curriculum among the following options: 4-strongly agree, 3-agree, 2-disagree, and 1-strongly disagree.

To ensure content validity of the crafted questionnaire, six curriculum developers and teachers from the Philippines and Japan were asked to rate it using a 4-level rating scale: 4-very valid, 3-valid, 2-somewhat valid, and 1, not valid. Collated ratings from the six curriculum developers and teachers were computed using Aiken's V validity estimation. An overall validity coefficient of 0.94 was computed which means that the crafted questionnaire is valid.

For the reliability or internal consistency of the questionnaire, 15 teachers from the Philippine Science High School campuses answered the survey. Gathered data were computed using Cronbach's alpha and showed excellent reliability with a coefficient of 0.98.

The validated and reliability-tested questionnaire was transformed in a Google Form® for easy administration and retrieval of data. This was also initiated due to travel restrictions and limited school access due to the ongoing Corona Virus pandemic. A survey questionnaire was administered to teachers from both STEM systems, i.e., Japan's SHS and Philippines' STEM HS, involved with the implementation of the project-based (research) curriculum. Overall, the questionnaire measures the extent of effectiveness of the project-based (research) curriculum according to the perspective of the teachers.

Data Analysis

Descriptive and inferential statistics were utilized to process the data that will be gathered from the survey on the extent of effectiveness of the research curriculum against the four dimensions of the Tylerian Model. Specifically, Mann-Whitney U-test was used to compare the difference between the perspectives of the teachers as to the extent of effectiveness of the project-based (research) curriculum along the four dimensions. Interpretation of the gathered data is detailed in table 2.0

Table 2.0 Transformed scale of interpretation for the teachers' perceived level of effectiveness of the project-based (research) curriculum

Statistical Range		Level of Agreement	Interpretation: Teachers Perceived Level of Effectiveness of the Project-based (research) Curriculum
3.50	4.00	Strongly Agree	Extremely Effective
3.00	3.49	Agree	Effective
2.50	2.99	Somewhat Agree	Moderately Effective
2.00	2.49	Somewhat Disagree	Slightly Effective
1.50	1.99	Disagree	Least Effective
1.00	1.49	Strongly Disagree	Not Effective at all

Results, Findings, and Discussions: Perceived Extent of Effectiveness of the Project-based (research) Curriculum

The succeeding sections present the extent of effectiveness of the project-based (research) curriculum as perceived by teachers from the Philippines and Japan. The prepared survey questions focused on four (4) main dimensions, including the formulated learning objectives of the project-based (research) curriculum; identified learning experiences in the curriculum to enable achievement of objectives; organization approaches of learning experiences; and evaluation methods of the project-based (research) curriculum. A comparative teachers' perception from the Philippines and Japan on the four dimensions are shown in table 3.0 on formulated learning objectives, table 4.0 on learning experiences, table 5.0 on organization approaches of learning experiences, and table 6.0 on evaluation methods.

Formulated learning objectives of the project-based (research) curriculum

Concerning the learning objectives of the project-based curriculum, teachers from the Philippines and Japan answered the question, "*What is the extent of effectiveness of the formulated learning objectives of the project-based (research) curriculum?*" along seven sub-dimensions: self-sufficiency, comprehensiveness, validity, interest, significance, utility, learnability, and feasibility. The evaluation questionnaire (see appendix A) details each subdimension.

Overall, Filipino and Japanese teachers pointed out that the overall effectiveness (Table 2.0) of the project-based (research) curriculum across the seven dimensions is "extremely effective", with the latter slightly rating their curriculum higher. This means that the teachers from both countries perceived that learning objectives set in the project-based (research) curriculum are exceptionally laid to suit the needs of the STEM students who will be pursuing scientific and mathematical research projects. Specifically, these teachers rated "self-sufficiency", "comprehensiveness", and "validity" of the curriculum as "extremely effective". This implies that the learning objectives embedded in the curriculum include contents or subject matter that can achieve the overall aim of the curriculum; that these objectives allow them to experiment, observe, and conduct field study; and that these objectives cover the three important domains of learning, that is, cognitive, affective, and psychomotor to allow holistic learning experience of the learners. Anderson et al. (2001) discussed that the diversity of learning tasks with the presence of these three domains creates a "comparatively well-rounded learning experience" for the students. In the context of the present research, the inclusion of these domains will target the significant points in learning the basics and complexities of research-making.

Table 3.0 Perceived effectiveness of the formulated learning objectives project-based research curriculum along the following subdimensions between Filipino teachers and Japanese teachers and their associated *p*-values

Subdimensions	Filipino Teachers X_{PH}	Japanese Teachers X_{JP}	*p*-values
Self-sufficiency	3.83 - EE	3.87 - EE	0.69
Comprehensiveness	3.77 - EE	3.87 - EE	0.36
Validity	3.74 - EE	3.83 - EE	0.14
Interest	3.83 - EE	3.91 - EE	0.52
Significance	3.83 - EE	3.87 - EE	0.69
Utility	3.83 - EE	3.74 - EE	0.47
Learnability	3.77 - EE	3.91 - EE	0.11
Feasibility	2.60 - ME	3.78 - EE	$<0.001^{**}$
Overall	**3.65 - EE**	**3.85 - EE**	**0.08**

Legend: EE-Extremely Effective; E-Effective; ME-Moderately Effective; SE-Slightly Effective; LE-Least Effective; NE-Not Effective at all
** significant at 0.01 level of significance

Furthermore, Filipino and Japanese teachers also rated the following learner-centred subdomains, "interest", "utility", and "learnability" of the project-based (research) curriculum as "extremely effective". Teachers find that the objectives set in the program are formulated according to the interests of the learners, that these are according to the usefulness of the content and subject matter to the learners, and that these objectives are aimed to maximize the learning capacity and experiences of the learners. This concurs with the study conducted by the Japanese Science and Technology (JST) agency which reported that students who like science and mathematics subjects responded that the whole SSH program helped them to have more interest in the scientific fields (Wada, n.d.). It is extremely important that learners are at the central point of an effective curriculum as underscored by Jagersma (2010). Jagersma stated that curriculum is constructed with the learner as its central focus as it enables teachers to devise experiences to develop lifelong learners and responsible citizens. When learners are put at the forefront of effective research curriculum planning, learners will be capable of crafting research that will be significant to them and the society beyond the walls of their classroom.

Lastly, in terms of the "feasibility" of the curriculum, Filipino teachers rated their curriculum significantly lower than how Japanese teachers rated theirs. Filipino teachers find that while objectives of the research curriculum are theoretically effective in the achievement of the overall aim of the research curriculum, that is, to develop an inquiry-based research project, available resources and allowable time to implement research topics are amongst pressing problems facing the research and development program of the Filipino teachers. In an in-depth interview with a Filipino research teacher, he said that learning resources including equipment to conduct scientific research proposals of the learners in science high schools are still scarce. While the curriculum's learning objectives are smartly crafted, the feasibility to implement such objectives is still a problem to many Philippine government schools implementing STEM programmes.

On the other hand, Japan's Super Science High Schools (SSH) are afforded with progressing budget to orchestrate the very goal of instituting the program set by MEXT, that is, to provide hands-on and problem-solving learning in the students' project-based study through observations and experiments, conducting the project-based study by individual student or groups (Hasegawa, 2010). In fact, according to the report by Hasegawa (2010), from 2010 to 2014, the total budget downloaded for the super-science high program has doubled from 2010 to 2014, proving the dedication of the Japanese education ministry to develop human resources in the scientific and technological field. Furthermore, to meet these goals, the JST pays all expenses of SSH's activities instead of SSHs themselves, hence, Japanese students are fully provided with both opportunities and resources to further their skills in developing scientific and mathematical research. This, therefore, confirms the high rating of Japanese teachers of the "feasibility" of the SSH project-based curriculum.

Identified learning experiences of the project-based (research) curriculum

For the second dimension of Tyler's object-centred model, teachers from the Philippines and Japan answered the question, *"What is the extent of effectiveness of the identified learning experiences in the curriculum to enable achievement of objectives*?". The teachers rated the second dimensions among the following subdomains: validity, comprehensiveness, variety, interest, relevance to life, and suitability. According to Okunloye (2014), these criteria are non-negotiable in the selection of learning experiences and must be consistent with the rest of the stages of curriculum development.

Table 4.0 Perceived effectiveness of the identified learning experiences of the project-based research curriculum along the following subdimensions between Filipino teachers and Japanese teachers and its associated *p*- values

Subdimensions	Filipino Teachers X_{PH}	Japanese Teachers X_{JP}	*p*-values
Validity	2.74 - ME	3.70 - EE	<0.001**
Comprehensiveness	2.86 - ME	3.52 - EE	0.003**
Variety	1.77 - LE	3.57 - EE	<0.001**
Interest	2.74 - ME	3.09 - E	0.11
Relevance to Life	3.94 - EE	3.96 - EE	0.83
Suitability	3.83 - EE	3.91 - EE	0.37
Overall	**2.98 - E**	**3.62 - EE**	<0.001**

Legend: EE-Extremely Effective; E-Effective; ME-Moderately Effective; SE-Slightly Effective; LE-Least Effective; NE-Not Effective at all
** significant at 0.01 level of significance

From table 4 we know that overall, Filipino teachers in select STEM schools in the Philippines rated the Department of Education's project-based (research) curriculum, "effective" while Japanese teachers from SSH rated their curriculum "extremely effective". This means that overall, Japanese teachers find their project-based curriculum filled with opportunities for students to interact with content toward its achievement, which includes experimenting and explorations. Filipino teachers, on the other hand, have significantly lower ratings than their Japanese counterparts along this dimension. These teachers feel that the learning experiences of the students including the learning opportunities, activities, teaching-learning strategies, and methods need to be enhanced to meet the overall aim of the project-based curriculum.

In terms of the individual subdimensions, Japanese teachers rated the following significantly higher than the overall response of the Filipino teachers: validity, comprehensiveness, and variety. This means, for the SSH's project-based curriculum, learning experiences set in it cover all the stated objectives of the research course and are holistic. This implies that according to Japanese teachers, research learning experiences in their respective project-based are set according to cognitive (e.g., development of a research topic, analysis of data, etc.), affective (e.g., research procedures are bound by ethical considerations, etc.), and psychomotor objectives (e.g., research experimenting, etc.). Furthermore, the learning experiences in the SSH's project-based curriculum are perceived to be varied and differentiated. This includes the use of different modalities such as attendance at research conferences with invited research speakers, exposure to research laboratories, among others. True enough, with Japan's Ministry of Education, Culture, Sports, Science, and Technology (MEXT) adopting the "Science Literacy Enhancement Initiatives" in 2002, SSH students are provided with comprehensive and varied learning opportunities for budding researchers in the senior high school. Students are provided with many opportunities to further their understanding of conducting research such as in fieldwork, laboratory and museum visits, and research conferences. The whole agency strongly supports "research invitation lectures" which invite researchers and technicians to conduct lectures at SSHs through cooperation between education units and universities, allowing the students to experience and learn cutting-edge technology (MEXT, n.d.). A large number of SSHs cooperate with their neighbouring university on project-based studies, such as Okayama University, Hiroshima University, Mie University, Osaka University, University of Tsukuba, among others (Hasegawa, 2010). By providing students with these learning opportunities, students are afforded practical and work-ready skills that apply to a real-life scenario and conceptualize and conduct research that can be utilized by their respective communities.

According to Kolb and Kolb (2005, p. 199), "true experiential learning can be labelled as an atmosphere created by the teacher to enhance the learning capacity of a learner". Accordingly, students who learn through project-based, experiential methodology can more readily grasp the first-hand intricacies of day-to-day life in real-world situations. Thompson and Edwards (2009) argued that learners who are engaged in projects related to real-world situations have proven to be a boon for not only the students but for the outside clients.

On the other hand, Philippines STEM schools, whilst seeing the importance of comprehensive and varied learning experiences for the students, are prevalently traditional (de Mesa & de Guzman, 2006), that is, learning concepts of the research course is still often limited to classroom teaching. This may be due to the following reasons: congested curriculum and lack of outside the school learning opportunity. In a report by Sunio (2018), the Philippines K to 12 curricula is cramped as compared to the other southeast Asian countries and claimed that students are confined inside the classroom for almost the whole year learning hundreds if not thousands of learning competencies stipulated in the curriculum with little to no exposure outside the school for fieldwork. The research curriculum for Grade 7 and Grade 8 alone are congested with competencies that are purely on knowledge learning rather than skill development. While some competencies require exposure to research laboratory techniques and attendance at research conferences, problem on the budgetary allotment to provide materials, learning resources, and attending symposia and conferences is still prevalent. Secondly, on lack of outside the school learning activities, opportunities to tie up with neighbouring universities and laboratories are still a struggle for many schools, for lack of support by the school administration, unavailability of official guidelines by the Department of Education in partnering with institutions for laboratory use and lectures, and non-reception of students by some research institutions. Teachers' initiatives, with little to no budgetary support, to seek agreement with outside institutions are often the cases happening in the country.

However, in terms of interest, relevance to life, and suitability, both Filipino and Japanese teachers rated highly. This means that learning experiences that are set in the project-based curriculum are of great interest to learners. Additionally, these learning experiences are perceived to be relevant to real-life situations, which implies that these experiences help learners understand their society and offer solutions to some problems through their project-based study. Lastly, both sets of teachers find that the learning experiences are suitable for the age or level of the learners and for the content for which it is meant. Research topics and procedures to be undertaken by the students are within their physical and mental capacity.

Organization approaches of learning experiences of the project-based (research) curriculum

The succeeding discussions deals with the third dimension of Tyler's objective-centred model deal centred on the organizational approaches of learning experiences of the project-based (research) curriculum (Tyler, 1976). In this part, Filipino and Japanese teachers answered the question, *"What is the extent of effectiveness of the organization approaches of learning experiences set in the project-based (research) curriculum?".* This Tylerian dimension is measured according to the following subdimensions: continuity, sequence, and integration.

Overall, both Filipino and Japanese teachers find that their respective project-based (research) curriculum "effective" in terms of the organization of learning experiences across the three subdimensions. This means both set of teachers perceive that learning experiences set in the project-based curriculum have continuity. This implies that learners acquire new knowledge and, with mastery, develop progressively, systematically, and naturally with new knowledge building on earlier acquired knowledge. For example, learners conceptualize a research topic based on their research interest and later develop this topic through experimentation and data collection, to arrive at new knowledge. Furthermore, they perceived that their curriculum has a "sequence" which implies that learning experiences set in the project-based curriculum progress from lower to a higher level of knowledge, and from simple to complex. For example, learners transition from understanding basic and integrated science process skills to utilizing the scientific method, from formulating research objectives to designing the experiment, etc. Lastly, these teachers pointed that there is "integration" of learning experiences. This means that learning experiences set in the project-based curriculum integrate several subjects and areas. Knowledge and skills in sciences, mathematics, and other related fields are used in doing the research process.

Table 5.0 Perceived effectiveness of the organization approaches of learning experiences along the following subdimensions between Filipino teacher and Japanese teachers and its associated *p*-values

Subdimensions	Filipino Teachers X_{PH}	Japanese Teachers X_{JP}	*p*-values
Continuity	3.46 – E	3.48 - E	0.90
Sequence	3.49 – E	3.26 - E	0.19
Integration	3.49 – E	3.35 - E	0.46
Overall	**3.48 – E**	**3.36 - E**	**0.36**

Legend: EE-Extremely Effective; E-Effective; ME-Moderately Effective; SE-Slightly Effective; LE-Least Effective; NE-Not Effective at all

For the Philippines STEM research curriculum, from table 5 we know that curriculum is anchored on the general approach of the K to 12 curriculums, which aims to ensure continued learning through spiral progression, and that the curriculum shall use pedagogical approaches that are constructivist, inquiry-based, reflective, collaborative and integrative (Republic act no. 10533). Perez, Bongcales, and Bellen (2020) discussed that the move of the Philippines to adopt the spiral progression approach of the recently implemented curriculum is a means to be at par with the curriculum of high-performing countries such as Japan. In the context of the project-based curriculum in the Philippines, there is an evident continuity, sequence, and integration of the curriculum which realizes the aimed salient features of the K to 12 curriculums. The findings of Perez et al corroborate with the finding of the current research in terms of the positive reception of the organization of the learning experiences set in the project-based curriculum. For the earlier study, teachers regard positively on the curriculum organization, "viewing it as a learner-centred, advanced, and sophisticated way of organizing the contents of a curriculum" (p.10). However, from personal correspondence with some implementers of the research curriculum, they pointed topics set for grades 9 and 10 are less organized as compared to the grades 7 to 8 learning experiences, including the absence of the third quarter topics. Hence, teachers for the fourth research class find difficulty in distributing the topics for the whole academic year especially in the said course which is implemented 4-days a week. Furthermore, the competencies for the fourth research course are found to be impossible to be implemented within classroom hours and within the school due to its time-demanding and laboratory-usage nature, when each class is only an hour-long, and laboratories are unequipped.

On the other hand, Japan's curriculum has demonstrated coherence as evident in their performance in international assessments such as Trends in Mathematics and Science Studies (TIMMS) and Programme for International Student Assessment (PISA). According to Tan (2012), Japan amongst others follows a spiral progression and integrated approach to coherently implement science and mathematics topics, allowing them to perform highly in international assessments. Tan further discussed that international assessment studies have integrated questions and are based on a spiral progression of concepts; hence, the result of these assessments reflects the success of the organization of learning experiences illustrated in the curriculum. While implementation of the project-based curriculum varies amongst super science high-designated high schools in Japan, the general approach of each curriculum is bounded by a coherent and integrated national curriculum.

Indeed, the organization of learning experiences is vital in the success of the curriculum. Furst (1950) argued that organization is important from the standpoint of the individual learner. Furst claimed that the extent to which various outcomes are organized may affect the individual's ability to generalize his learning from one content field to another and broader areas of everyday life. Without such organization, the possibilities of transfer and generalization are greatly limited and the individual's behaviour patterns may remain relatively compartmentalized. Thus, he may be effective in solving problems in one kind of situation but not in another. And even in a problem situation of a similar kind, he may not be able to interrelate effectively the kinds of reaction required for a satisfactory adjustment or solution.

Evaluation methods of the project-based (research) curriculum

The discussion that follows covers the perceived effectiveness of the evaluation methods of the project-based (research) curriculum. Filipino and Japanese teachers involved in the implementation of the research curriculum answered the question, *"What is the perceived effectiveness of the evaluation methods of the project-based (research) curriculum along specific dimensions?"*.

Teachers rated their respective curriculum among the following domains: variety, effectiveness, validity, and comprehensiveness.

Generally, the teachers from the Philippines and Japan who are involved in the implementation of the project-based curriculum in their respective special science high school programmes perceived that evaluation methods incorporated in their project-based curriculum are effective. Firstly, there is a variety of methods used to assess and evaluate the attainment of goals of the project-based (research) curriculum other than written tests. Secondly, the tools of assessment employed within the assessment and evaluation process are used to effectively evaluate the attainment of the project-based (research) curriculum goals and objectives. Thirdly, in addition to assessing the cognitive development of the students, affective and psychomotor domains are included in the assessment providing a holistic assessment system of students learning. Lastly, the assessment and evaluation process is conducted in such a way as to assess comprehension, application, and evaluation of research knowledge and skill rather than mere retention of information.

Table 6.0 Perceived effectiveness of the evaluation methods of the project-based research curriculum along the following dimensions between Filipino teachers and Japanese teachers and its associated *p*-values

Subdimensions	Filipino Teachers X_{PH}	Japanese Teachers X_{JP}	*p*-values
Variety	3.46 - E	3.48 - E	0.67
Effectiveness	3.46 - E	3.43 - E	0.95
Validity	3.37 - E	3.43 - E	0.49
Comprehensiveness	3.54 - EE	3.48 - E	0.80
Overall	**3.46 - E**	**3.46 - E**	**0.55**

Legend: EE-Extremely Effective; E-Effective; ME-Moderately Effective; SE-Slightly Effective; LE-Least Effective; NE-Not Effective at all

From table 6, both the Philippines and Japanese curricula adhere to a variety of assessments in terms of evaluating the attainment of learning objectives set in each project-based curricula. Various forms of assessments are incorporated in these curricula including the traditional written assessments, assignments, and progressive or alternative assessments such as collective portfolios, reflective essays, oral presentations, laboratory work, research reports (both paper output and multimedia presentation), amongst others. Rust (2005) underscored the importance of developing a variety of assessment methods. Rust pointed out that when one varies methods in the assessment of student learning, it covers effectively the other three subdimensions of this domain, that is, variety enables assessment beyond cognitive learning which is commonly assessed in a typically written assessment.

However, one major difference between assessment practices of the two sets of teachers is that Japanese lessons promoted conceptual understanding and problem-solving in which students are freely allowed to use the class time for conceptualization, planning, experimentation, gathering of data, and presentation, with minimal supervision of the teachers (Hattori & Saba, 2008) heavier than Filipino teachers do. Accordingly, with the introduction of inquiry-based and project-based learning in Japan, “deep learning, dialogical learning, and self-directed learning” (p. 38) were highlighted to engage active learning in high school education (Shimojima & Arimoto, 2017). Shimojima and Arimoto indicated that “inquiry and project-based learning not only learning to promote both traditional competencies and new 21st century skills but also require the transformation of assessment process and strategies” (p.39). Hence, this enables Japanese teachers to accommodate assessment methods that engage Japanese students to achieve 21st-century skills. Interestingly, Japanese assessments are anchored into sociocultural contexts. These include *hansei* (reflection, a method used in Japanese schools for self-improvement, often collaborative self-improvement), *kodomo ni yorisou* (building rapport with the children), *Kodomo o mitoru* (understanding children), amongst others. Mikouchi, Akita, and Komura (2018) discussed further Japanese assessments for project-based learning are grounded on “knowledge structure and metacognitive” (p.375). Newer assessment tools besides traditional examinations are promoted. These include self-assessments, portfolio assessments, oral communication, amongst others.

Filipinos, on the other hand, still prevalently relied on traditional assessments, that is, viewing the teachers as the dispenser of knowledge. There is a significant attempt to transition to a lesser traditional approach in the Philippine classroom, especially in the context of teaching the project-based (research) curriculum such as for the oral presentation of research papers, especially that various forms of formative and summative assessments (both individual and collaborative) are encouraged by the Department of Education (DepEd Order No. 8, s. 2015). However, going back to the problems of lack of resources, teachers are left with no choice but to stick to the traditional approach of implementing the curriculum. Furthermore, beyond lack of materials for holistic assessment of attained objectives, other factors also play a significant role as to why many have heavily used traditional assessment approaches. In a study by Lasaten (2016), he found out that “paper and pencil” assessment methods such as multiple-choice tests, essay tests, amongst others are still a top choice amongst Filipino teachers due to its easier facilitation, checking, and scoring. Several pieces of research (Navarro & de Guzman-Santos, 2013; Senk, Beckmann, & Thompson, 1997; Taylor, 2010) also concluded that many teachers are still confined to conventional practices of assessment, due to familiarity and easiness of its facilitation. This concurs with the personal correspondence made with some teachers in the Philippines who affirmed that many research assessment practices still relied on the use of traditional assessment particularly on periodical assessment, assignments, quizzes, amongst others.

Furthermore, many teachers teaching the course are inexperienced in doing research, let alone facilitating a class on scientific research and mathematics research (Manalo, personal communication, December 23, 2020). Many of these teachers are assigned from a pool of mostly science teachers who may not necessarily have the experience of teaching the subject. Doganay and Ozturk (2011) pointed out that inexperienced teachers have poorer judgments in conducting and implementing classroom assessments affecting the overall performance of the learners, and the failure to attain the intended objectives of the curriculum. They suggested that in-service programs covering various topics including classroom assessment must be conducted to promote metacognitive strategies into their classes.

Summary, Conclusions, and Recommendations

Both the Philippine STEM Junior High School system and Japan's Super Science High School system are founded on the same general idea, which is to provide advanced learning experiences for gifted and advanced students through the offering of advanced curricula that emphasize a higher understanding of the sciences and mathematics. Both systems believe in the importance of research and see it as an integral part of the whole STEM implementation in the basic education through the project-based (research) curriculum).

The present study attempted to quantitatively compare perceptions of the teachers as to the effectiveness of their respective project-based (research) curriculum along the four dimensions of Tyler's Objective-centred Model: (1) learning objectives; (2) learning experiences; (3) organization of learning experiences; and (4) evaluation methods. The perceived effectiveness of the learning objectives for both systems is very high citing that these objectives are laid out clearly to suit the needs of STEM students pursuing scientific and mathematical research. However, with the problem of resources available, the Philippines finds a lack of confidence in the feasibility in the achievement of some of its set objectives in which Japanese teachers do not find a significant predicament. On the other hand, Filipino and Japanese teachers differ in their perceptions of the effectiveness of the learning experiences, in which the former indicates lower favourability of their set learning experiences which are limited to classroom teaching and theoretical knowledge acquisition with few to no practical knowledge acquisition. Furthermore, in terms of the organization of these learning experiences, the Philippines and Japanese project-based curricula are perceived to be effective. Personal experiences of some Filipino teachers reveal a lack of organization in the latter research courses due to missing learning competencies and its non-feasibility to be implemented. Again, this boils down to one major reason for the Philippines side, that is, lack of resources, funding, facilities (Rita, 2020), and support from the local to national government units (Julve, 2018). This is in contrast with the implementation of the curriculum in SSH-designated schools in which various Japanese funding authorities put priority in this area (JST, 2010). Lastly, Filipinos and Japanese teachers perceived similarly high effectiveness in the evaluation of the project-based (research) curriculum with differences in assessment practices. The latter implemented conceptual understanding and problem solving while the former prevalently relied on traditional assessments.

The Philippine implementation of the project-based research curriculum in special science high schools can learn a lot from their Japanese counterpart who has been successful and nationally recognized (MEXT) for introducing innovative practices for effective acquisition of both theoretical and practical knowledge about research. Philippine's curriculum must emphasize a balance of these two types of knowledge to develop human resources of well-rounded and holistic STEM professionals in the future. With the decline of the performance of Filipino students in international assessments in which Japanese students are ranking highly, a shift into this kind of theoretical and practical-based curriculum may just be the key.

Furthermore, the Philippines Department of Education, whilst having allocated funding for STEM schools, must ensure that implementing rules and guidelines for its use are strictly followed and enforced. Furthermore, the department must give more fund allotment, support, and priority to STEM-implementing schools for teacher development, purchase of equipment, setting up of facilities, and amenities, to ensure that the learning experiences of students go beyond theoretical knowledge acquisition.

Bibliography

Anderson, L.W., Krathwohl, D.R., Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., Wittrock, M.C. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.* Pearson, Allyn & Bacon

Anh, V.T.K. (2018). Evaluation models in the educational program: Strengths and weaknesses. *VNU Journal of Foreign Studies,* 34(2), 140-150.

Ary, D., Jacobs, L., Sorensen, C. & Razavieh, A. (2010) Introduction to research in education (8th Ed). Cengage.

Bilbao, P. P., Lucido, P. I., Iringan, T. C., & Javier, R. B., (2008). Curriculum development. Lorimar Publishing, Inc.

Curriculum evaluation. (n.d.). *Curriculum management.* https://www.sagepub.com/sites/default/files/upm-binaries/44333_12.pdf

Department of Education. (2004). The revised curriculum of the 110 S & T oriented (ESEP) high schools (DepEd Order No. 41, s. 2004). https://www.deped.gov.ph/wp-content/uploads/2004/06/DO_s2004_041.pdf

Department of Education. (2010). Policies and guidelines on strengthening science and mathematics education at the secondary level (DepEd Order No. 55, s. 2010). https://www.deped.gov.ph/wp-content/uploads/2010/05/DO-No.-55-s.-2010.pdf

Department of Education. (2014). FY 2014 guidelines on the utilization of financial assistance to schools implementing special curricular programs (DepEd Order No. 15 s. 2014). https://www.deped.gov.ph/wp-content/uploads/2014/03/DO_s2014_015.pdf

Department of Education. (2015). Policy guidelines on classroom assessment for the K to 12 basic education program (DepEd Order No. 8, s. 2015). https://www.deped.gov.ph/wp-content/uploads/2015/04/DO_s2015_08.pdf

Department of Education. (2017). K to 12 curriculum guide: Special science program for Research.

Department of Education, Culture, and Sports. (1993). Science high schools (DECS Order No. 69, s. 1993). https://www.deped.gov.ph/wp-content/uploads/2018/10/DO_s1993_69-1.pdf

Doganay, A. & Oztur, A. (2011). An investigation of experienced and inexperienced primary school teachers' teaching process in science and technology classes in terms of metacognitive strategies. *Education Sciences: Theory and Practice,* 11(3), 1320-1325.

Hasegawa, T. (2010). *Super Science High School (SSH)* [PowerPoint slides]. Japan Science and Technology Agency. https://www.jdzb.de/fileadmin/archiv/media/p1335ppt-hasegawa.pdf

Hattori, K. & Saba, A.N. (2008). Comparison of classroom assessment practices: A case of selected Ghanaian and Japanese mathematics lessons. *NUE Journal of International Educational Cooperation,* 3, 95-105. https://www.naruto-u.ac.jp/_files/00107754/journal_03_12.pdf

Mikouchi, A., Akita, K., & Komura, S. (2018). A critical review on project-based learning in Japanese secondary education. Tokyo University research repository

Ministry of Education, Culture, Sports, Science, and Technology (n.d.). Human resources in science and technology are required of Japan in the future. https://www.mext.go.jp/b_menu///hakusho/html/hpag200301/hpag200301_2_019.html

Kettler, T., & Puryear, J. (2018). Curriculum, methods, and authentic experiences in science and mathematics specialized schools.

Specialized Schools for High-Ability Learners: Designing and Implementing. Sourcebooks, Incorporated.

Kolb, A. V., & Kolb, D. A. (2005). Learning styles and learning spaces: enhancing experiential learning in higher education. *Academy of Management*, 4(2), 193-212.

Jagersma, J. (2010). Empowering students as active participants in curriculum design and implementation. https://files.eric.ed.gov/fulltext/ED514196.pdf

Japan Science and Technology Agency (2010). What are super science high schools. *Education in Japan.* https://educationinjapan.wordpress.com/the-scoop-on-schools/what-are-super-science-high-schools/

Julve, C (2018). Not an issue of affordability but lacking in support and priority. *Inquirer.net.* https://opinion.inquirer.net/110554/not-issue-affordability-lack-support-priority

Lasaten, R.C.S. (2016). Assessment methods, problems and training needs of public high school teachers in English. *International Journal of Languages, Literature and Linguistics,* 2(2), 55-60. http://www.ijlll.org/vol2/67-LL0007.pdf

Navarro, N.L. & de Guzman-Santos (2013). *Authentic assessment of student learning outcomes: Assessment of learning 2, 2nd ed.* Lorimar Publishing, Inc.

Okunloye, R.W. (2014). Do social studies teachers' variables influence students' performance in senior high school social studies in Ghana? Evidence from students' performance in social studies. *Journal of Education Practice,* 2(35).

Perez, J.C.S., Bongcales, R.C.A., & Bellen, J.A. (2020). A scoping review on the implementation of the spiral progression approach. *Journal of Academic Research,* 5(3).

Philippines. (2013). Republic Act no. 10533: An act enhancing the Philippine basic education system by strengthening its curriculum and increasing the number of years for basic education, appropriating funds therefor and for other purposes. Official Gazette, Republic of the Philippines

Popham, W. J. (1995). Educational evaluation (3rd edition). Boston: Allyn and Bacon.

Rita, J. (2020). Lacson laments the lack of funding for research and development amid the COVID-19 pandemic. *GMA News Online.* https://www.gmanetwork.com/news/scitech/science/760640/lacson-laments-lack-of-funding-for-research-and-development-amid-covid-19-pandemic/story/

Rust, C. (2005). Developing a variety of assessment methods. Enhancing practice: reflections on assessment.

Science and technology system reform (2008). *White Paper on Science and Technology.* https://www.mext.go.jp/component/english/__icsFiles/afieldfile/2011/02/22/1302491_009.pdf

Senk, S.L, Beckmann, C.E., & Thompson, D.R. (1997). Assessment and grading in high school mathematics classroom. *Journal for Research and Mathematics Education,* 28(2), 187-215. https://doi.org/10.2307/749761

Shimojima, Y. & Arimoto, M. (2017). Assessment for learning practices in Japan: Three steps forward, two steps back. *Assessment Matters,* 11. http://dx.doi.org/10.18296/am.0023

Sunio, R. (2018). PH's K to 12 is still congested. *Sun Star. https://www.sunstar.com.ph/article/1656074/Cagayan-De-Oro/Opinion/Sunio-PHs-K-to-12-is-still-congested?seeMore=1*

Tan, M.C. (2012). *Spiral Progression Approach to Teaching and Learning* [PowerPoint slides]. National Institute for Science and Mathematics Education Development, University of the Philippines, Diliman, Quezon, City. https://docplayer.net/32725812-Spiral-progression-approach-to-teaching-and-learning.html

Taylor, C.S. (2010). Using portfolios to teach teachers about assessment: How to survive. *Educational Assessment.* 4(2), 123-147. https://doi.org/10.1207/s15326977ea0402_2

Thomas, J., & Williams, C. (2010). The history of specialized STEM schools and the formation and role of the NCSSSMST. *Roeper Review*, 32(1), 17-24.
Thompson, J.B., & Edwards, H.M. (2009). Preparing graduate students for industry and lifelong learning: A project-based approach. *Education and Technology for a Better World*. Springer Berlin Heidelberg
Tyler, R. (1949). Basic Principles of Curriculum and Instruction. The University of Chicago Press.
Tyler, R. W. (1976). Two new emphases in curriculum development. *Educational Leadership*, 34, 61.
Vo, T.K.A. (2018). Evaluation models in education programs: Strengths and weaknesses. *VNU Journal of Foreign Studies,* 34(2), 140-150. https://www.researchgate.net/publication/330002563_Evaluation_models_in_educational_programs_Strengths_and_weaknesses
Wada, K. (n.d.). Opportunity for development of academic culture in the super science high school project. https://www.apu.ac.jp/rcaps/uploads/fckeditor/publications/polyglossia/Polyglossia_V14_Wada.pdf
Wang, X., Wang, X., & Meng, X. (2016). Consideration of the post-education course examines mechanism innovation. *3rd International Conference on Management, Education Technology and Sports Science.*

2021

SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 1, No: 2, PP:18-27
www.journal.qitepinscience.org

Research Paper Open Access

Using of Game-Based Learning via Facebook Live to Enhance Distance Learning in the Time of COVID-19 Pandemic

N Saengprachum[1]

[1]The Institute for the Promotion of Teaching Science and Technology (IPST), Bangkok, Thailand
nisae@ipst.ac.th

Abstract

The use of current and emerging platforms in education is becoming an intriguing topic among educators and educational institutions. Using live-stream media like Facebook lives can provide a more intimate level of engagement with audiences. Besides, the use of games in education plays a vital role in engaging students by encouraging a hands-on approach. This study aimed to investigate implementing a game-like via Facebook live feature as a supportive science learning tool. This study examined how Thai secondary school teachers and students performed and interacted with five live-streaming activities. In each live-stream activity, the participants needed to answer ten questions in the scheduled time. The resource used for posing questions is secondary school science materials related to the Thai Basic Education Core Curriculum's learning standard. The participants were required to join the live-stream video as well as answer ten questions in real-time. All participants were provided materials uploaded on the Facebook wall two days before the live-streaming day. The result of this study showed that the number of participants who scored more than the given criteria had steadily increased, suggesting that the Facebook live feature is a useful tool for learner engagement. It indicates that the Facebook live feature increases students' motivation and attention since it can enhance visual skills, improve students' interaction and collaboration abilities with their peers.

Introduction

The outbreak of the coronavirus disease-2019 (COVID-19) has made significant disruptions to the Thai education system. This pandemic caused school closures in Thailand. A new normal education system is expected after the COVID-19 is under control [1]. So providing education during the coronavirus disease (COVID-19) outbreak is a challenge[2]. Most Thai students and teachers have adapted to the new normal following the COVID-19 pandemic. Thailand has been arranging a distance learning approach via satellite or DLTV (Distance Learning Television) since the reign of His Majesty King Bhumibol (King Rama IX), who had an excellent vision in bridging the knowledge gap for learners in rural areas. On this crisis, Thailand has an opportunity to adopt this approach for underprivileged children and youth for all learners nationwide. The online learning platform is also an alternative solution [3,4]. Students can always access learning materials such as module contents, assignments, and recorded sessions anytime and anywhere with an online learning platform. Besides, online courses transfer classroom learning in the virtual environment with no physical interactions. Parents could support education leaders and teachers to assess different ways to continue educating students during the COVID-19 Pandemic [5,6]. However, when students participate in a lecture for an hour online, it goes beyond passive into insensible. Finding ways to bring active learning into the online environment is necessary. Active learning refers to the idea that students are actively engaged in the learning process rather than passively absorbing content[7]. There are many examples of active learning strategies adapted for online learning, such as assessment - tests and quizzes that provide immediate feedback, discussions (virtual chat, bulletin board), games and simulations, and community building.

Gaming is a type of play where participants follow defined rules. Many different types of games are being applied and used in educational institutions [8]. The correlation between the game cycle and learning outcome is shown in Figure 1. The game-based learning model provides a link between simulation-based activities and the real world and associates events in the Game with real-world events. The game-based learning model has successfully carried out informal education, such as military, medicine, and physical training [7]. Michel (2016) remarked that games with encouraging curriculum content or other educational materials are educational games [8]. Also, games can be used as a support tool to complement traditional teaching methods to improve the learners' learning experience while also teaching other skills such as following rules, adaptation, problem-solving, interaction, critical thinking skills, and creativity [9]. Many platforms can support online learning, such as Facebook, Zoom, and line application.

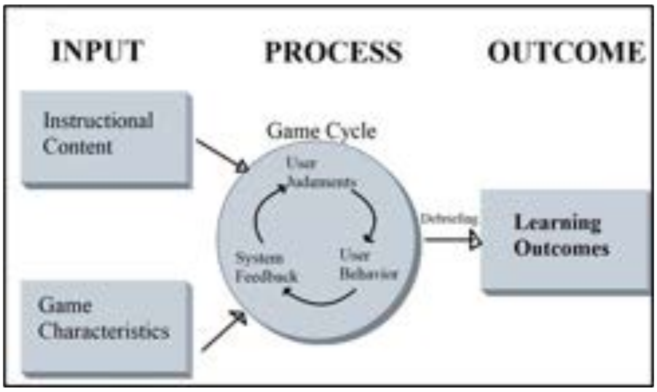


Figure 1. Game-Based learning model[9] .

In Thailand, both social media and technology have become an indispensable part of Thai society. Every individual aged above 13 years old will have their account on popular social media networks such as TikTok, Instagram, Snapchat, and Facebook [10–12]. Social media allows active participation in activities and services by sharing content and opinions and supporting online groups' creation according to the participants' specific needs[10,13,14]. Social media advantage in education is an engagement tool that encourages new teaching methods and effective communication between students and teachers worldwide. Teachers can upload teaching or educational videos on social media such as YouTube, Facebook, Twitter, and Instagram to educate students worldwide. Moreover, social media could enhance students' performance, help the student become more active and engage in learning [5].

Facebook is one of the biggest social media networks globally. According to the Q3 2019 report, 74% of Facebook users visit the platform daily. Hence, it can be a useful tool for the instructor to share learning resources, fire up discussions, promote collaboration, improve relationships between students, and incorporate various learning tools—such as videos, images, boards, chatting, and private messaging.

Facebook Live is a Facebook feature that allows users to stream live videos to a Facebook Page or Group. Besides, applying Game-Based learning with Facebook Live can bring active learning into the online environment [15]. Therefore, Game-Based learning with Facebook Live could be used as a support tool to Enhance Distance Learning Engagement in the Time of COVID-19 Pandemic.

In this paper, Facebook appears to be used primarily as a supportive tool in game-based learning for science subjects. The study's goal was to determine if the implementation of Game via live-stream feature would encourage students' and teachers' online learning during the COVID-19 pandemic.

Methods

2.1 Materials

The tools for live streaming composted of a desktop computer, stable internet connection, and a mobile phone. Besides, Facebook and OBS-Studio Application are the platforms that are used to support an online educational game.

2.2 Participants

This study's participant was random of teachers and students from primary school to high school who register in the google form.

2.3 Research Design

This qualitative research introduced game-based learning (GBL) in science education via Facebook Live to enhance distance learning in the COVID-19 pandemic. This study aims to bring active learning into the online environment and maximize learners' voluntariness to study and answer real-time questions. The data in this study were collected using online surveys. The process for managing game-based learning through Facebook Live consists of seven stages, namely (1) Learning resources preparation, (2) Scheduling and activity promotion, (3) Registration, (4) Updating learning resources, (5) Live-stream broadcasting, and (7) rewarding:

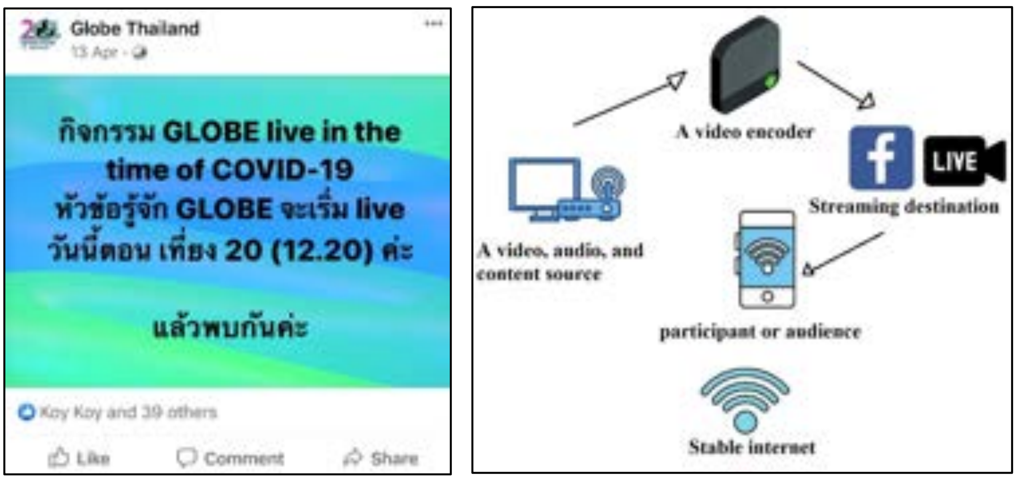
Firstly, learning resources for question designing were collected from books, social media, and the Globe Thailand website. The selected sources are relevant to the secondary school science level. Each topic is related to the Thai Basic Education core curriculum's learning standard, as can be seen in Table 1[16]. Each topic was considered in the developed ten questions—secondly, Scheduling and activity promotion. Set up scheduling is an essential part of planning online activities. In this study, each day's activity time was set at 12:20 pm because this is the time that participants hang out online most often. Hence, the scheduled date and time criteria, application form's link, and directions during the broadcast activity were posted on the Facebook wall, allowing the audience to decide ahead of time.

Table 1. Topics, Resources' Contents, and Standard Indicators**.**

Topic	Resources' Contents with the provided links	Standard Indicators and Grade Level
Knows GLOBE	- GLOBE 20 anniversary, https://www.youtube.com/watch?v=CsoVO54I3AM - Save the world (PM2.5) https://www.youtube.com/watch?v=jFeACJKpQhY	General knowledge Grade: All
Promotion of Soil Measurement	Soil fertility and pH, Soil Texture, - Soil observer cartoon http://globethailand.ipst.ac.th/media.php?p=3 - Soil Temperature https://www.youtube.com/watch?v=pIANGIkOSV8	Standard Sc1.2, Sc3.2 Grade 4, 7, and 8

Topic	Resources' Contents with the provided links	Standard Indicators and Grade Level
Climate Change	Storm, Flood, The effect of climate change and Preparing for changes, - Landslide https://www.youtube.com/watch?v=OaJfYAp7gVA - Climate Change https://www.youtube.com/watch?v=z1ybJRoUEqc	Standard Sc3.2 Grade 3, 5, 7, and 8
Promotion of Water and Atmosphere Measurement	Dissolved oxygen, Water temperature, Relative humidity, - Clouds covered https://www.youtube.com/watch?v=ca9yetBlip4 - Mosquitos https://www.youtube.com/watch?v=tQD_3qnamMI - Water transparency https://www.youtube.com/watch?v=ePU6OJyr4_I	Standard Sc1.1, Sc2.3 Grade 3, 5, 7, and 8
Promotion of Biosphere/Land Cover Measurement and the Earth System Science	Land cover, Trees circumference measurement, - Tree is sleeping https://www.youtube.com/watch?v=x8A33NWJvMU - Where the animal is https://www.youtube.com/watch?v=UivCv0U5ib8 - Tree height https://www.youtube.com/watch?v=_v0mJIlRd5Y	Standard Sc1.1, Sc.2.1 Grade 5, 7, 9

Thirdly, for the registration, the participants were asked to register through an online registration form. The online registration lets participants sign up for activity events anytime and anywhere before the activity date. Fourthly, Updating learning resources. In this section, online learning links video lectures, tutorials, online courses, and e-books which are informal online learning resources posted on the Facebook wall. Participants were assigned to study on the provided resources before joining the activity. The learning resources were posted on the Facebook wall every two days before the activities started. Then, participants could access the learning resources and study the topic that related to the questions.



(a) (b)

Figure 2. A compelling description: "GLOBE live in the time of COVID-19 in the topic of Know GLOBE will start at 12:20 pm" (a); The basic setup and flow of a live stream (b).

Fifthly, Live-stream broadcasting. Live-streaming broadcasting is a significant phase that would begin by writing a compelling description before starting the live-streaming video, as seen from Figure 2(a). The participants tend to engage with the activity more increase view duration. Then, check the video and audio sources such as cameras, computer screens, and other image sources, microphones, and other sounds to be played in the stream. After that, install a video encoder that packages real-time video and sends it to the internet. Next, start a live-stream broadcast on Facebook. A stable internet connection is essential, so streaming does not freeze, buffer, or drop off entirely. The basic setup and flow of the live stream were shown in Figure 2 (b). After the broadcast, the participants would receive a notification that a Facebook they follow was live. Finally, participants needed to enter to join live-streaming videos and answer questions in real-time at the scheduled time. The activity started with the host reading each question, and participants would have a response time of 20 seconds, reading three choices and typing the answers. Live streaming was ended after ten questions were asked. Figure 3 shows a sample of live-streaming activity.

Figure 3. Live-stream activity on April 20, 2020.

Sixthly, rewarding. There are two criteria for rewarding participants, which are the ones who have corrected at least seven from ten questions and the ones who joined five times activities with the highest cumulative total points known as the winner of the Facebook Live. To encourage and motivate participants to participate in the next activity, the names of participants who scored more than the given criteria were posted on the Facebook wall on the following day (Figure 4 (a)). Also, participants could learn more about the questions from the answers revealed and posted on Facebook wall.

Seventh, the survey was divided into two parts: a five-point Likert-scale six questions section, and three open-ended questions sections. The students were asked to fill the survey with a five-point Likert-scale seven questions section, while teachers need to fill both sections. To assess the level of the experience and knowledge of the participants on game based-learning, the responses were scaled by Likert values from 1 to 5: Not Satisfied at all, Not Satisfied, Neutral, Satisfied, Strongly Satisfied. The google form of the survey was delivered at the ending of the activities via a link (Figure 4 (b)).

(a) (b)

Figure 4. The names of participants who scored more than the given criteria and the answers were posted on a Facebook wall (a); The QR code for evaluating live-streaming activity (b).

2.4 Data collection and Analysis.

In this study, a survey was developed to evaluate the participants' experience and knowledge of game-based learning via the Facebook live platform. A five-point Likert-scale six questions are (1) Do you gain knowledge from participating in the activity? (2) Does the content of the activity modern and can be applied in life?, (3) Does the timing of the event appropriate?, (4) Does the activity provides fun and enthusiasm while participating? (5) Dose the plate form (Facebook life) appropriate?, and (6) Does the content appropriate?. Whereas Three open-ended questions are (1) Do you think this activity can be applied to the school? (2) Do you think that using Facebook Live can enhance Distance Learning Engagement, and (3) Do you have any other comments, questions, or concerns?

2.5 Data analysis technique

The data of this research was hand analysed because the number of data is a small group. The stages of data analysis were carried out (1) preparing and organizing data for analysis, (2) exploring and coding data, (3) creating codes to compile descriptions, (4) representing and reporting findings, (5) interpreting findings, and (6) validate the accuracy of the findings [17].

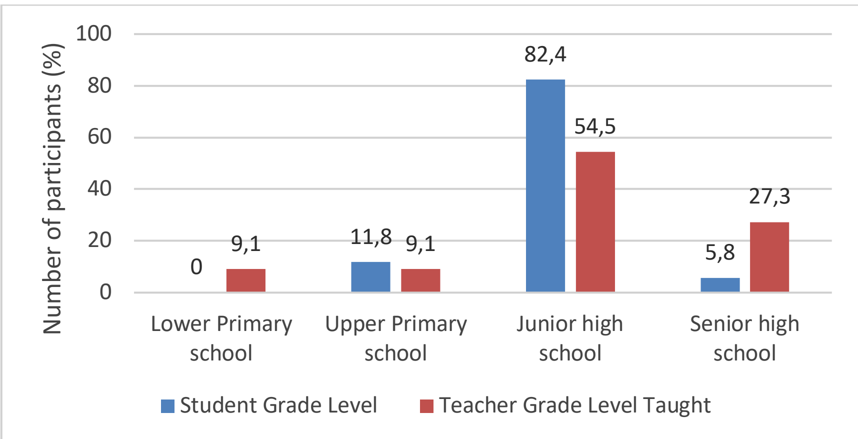
Result and Discussion

The results in this research were obtained from real-time responded participants and an online survey. Table 2 shows total likes, total shared, number of viewers, and participants' scores for real-time responded participants. After conducting the activities five times, it showed that the number of viewers who log onto Facebook on live-streaming events varies between 303 and 453 viewers. Indeed, there are two criteria for rewarding participants, which are the ones who have corrected at least seven from ten questions and the ones who joined five times activities with the highest cumulative total points known as the winner of the activity. At the first-time activity, 50% of participants scored more than seven. Then, it was noticed that the percentage of participants who got at least a score of seven had been increased steadily from 50% to 90% from the first-time activity to ending live-stream event. According to the result, the number of participants who get score more than the criteria have increased. Thus, this can be implied that participants improved their self-study with online resources. Also, answering more and more questions will allow more participants to correct more questions [18]. On the pandemic crisis, self-study on an online resource is an excellent method that enables learners to continue their studies effectively and efficiently[19].

Table 2. Total likes, total announcements shared, viewers, and the number of participants' scores.

No.	Total Viewers (person)	Total Announcements Shared	Number of Real-Time Participants (person)	Score ≥ 7 (person)
1	446	11	33	15
2	453	12	35	28
3	303	5	34	29
4	374	8	39	36
5	449	9	31	29

Figure 5 represents the level of student grade, and teacher grade taught, who participated in the live-stream activity. There are three student grade levels joined the activity since Facebook does not allow children under age 13 to create their own Facebook accounts. However, the results reveal that children under 13 may be on Facebook by using false information to sign up. According to the results, what is consistent is that the highest percentage was junior high school students (82.4%), followed by the upper primary school (11.8%) and senior high school (5.8%). The junior high school teacher was the most significant participant (54.5%), followed by senior high school teachers (27.3%). The third was upper primary school teachers (9.1%) and lower primary school teachers (9.1%). Thus, this two-way communication approach is for most junior high school students and teachers.



n for student grade level =54; n for teacher grade level taught = 48

Figure 5. Percentage of student grade level and teacher grade level taught participated in the live stream activity

It can be said from figure 5 that this online approach is innovative because it modelled the traditional two-way communication in face-to-face classrooms to online. This approach developed authentic relationships between teachers and students. Therefore, the key to success in online teaching is building a repertoire of tools that allow the teacher to have authentic communication with online students.

Questionnaires	Mean	
	Teachers	Students
The knowledge gained in each activity	4.4	4.3
The content of the activity is modern that can be applied in life	4.5	4.1
The timing of the event is appropriate	4.1	4.0
Have fun and enthusiasm while participating in activities	4.4	4.2
Appropriateness of platform (Facebook Live)	4.3	4.0
The appropriateness of content	4.3	4.1

Table 3. Mean of the activity rating using a five point Likert scale.

After the live streaming ended, the participants were asked to fill the survey for evaluating the activity through an online form. For the first section, both teachers and students were asked six questions to indicate the activity's rating shown in Table 3. The six questions, among them, are (1) Do you gain knowledge from participating in the activity? (2) Does the content of the activity modern and can be applied in life?, (3) Does the timing of the event appropriate?, (4) Does the activity provides fun and enthusiasm while participating? (5) Dose the plate form (Facebook life) appropriate?, and (6) Does the content appropriate? This assessment question uses guidelines from Likert values from 1 to 5 (not satisfied at all, not satisfied, neural, satisfied, strongly satisfied). Based on Table 3, a mean of 4.5 indicated that teacher-rated their satisfaction with the activity's content is modern that can be applied in life. A mean of 4.4 indicated that teacher-rated their satisfaction with the knowledge gained in each activity and have fun and enthusiasm while participating in activities. A mean of 4.3 indicated that teacher-rated their satisfaction with the platform's appropriateness (Facebook Live) and the content's appropriateness. The timing of the event is appropriate was rated at a mean of 4.1. For students, the highest mean is 4.3, with the knowledge gained in each activity followed by, have fun and enthusiasm while participating in activities with 4.1 of the mean. It can assume that students were engaged in this activity as they are more likely to follow the activity's rules and excited to participate. The lowest mean of the student is the same as the teacher. The evaluation results revealed a significant finding that teachers and students are satisfied with this approach as the mean was in the range of 4 to 5. From three open-ended questions as follow:

- Do you think this activity can be applied to the school?
- Do you think that using Facebook Live can enhance Distance Learning Engagement?
- Do you have any other comments, questions, or concerns?

Teachers who participated in this activity recognize the potential of using Game-based learning with Facebook live; that is an excellent pedagogy in this COVID 19 pandemic. This approach could engage students in online self-learning. Student engagement is crucial because it's linked to increased student achievement**[20]**. Using this Game-based learning approach, students tend to read assigned online resources more thoroughly as can be seen as the results in increasing the number of participants who passed the criteria (table 2). Most teachers noted that students could learn more effectively at their place because students can access many resources related to the assigned topic. Also, teachers agreed that using Facebook live is one of the platforms that support distance learning. There is a concern of using this approach: equity and accessibility to technology **[21,22]**. Moreover, participating in this activity can help students focus on memory because of this activity in real-time. It could mean that game-based learning via Facebook is an excellent pedagogy approach in the COVID-19 pandemic.

Conclusion

Continue quality learning for Thai students during the COVID-19 pandemic is a challenge for Thailand. Ministry of Education has been preparing to bring about online learning platform solutions to help tackle this problem. This research introduced Game-based learning with science learning via Facebook live as an optional way to promote distance learning engagement. This approach could engage students in online self-learning with motivation. From an open-ended questions survey, teachers agreed that using Game-based learning with Facebook live is one platform that could support distance learning. Besides, Game-based learning helps to bridge the online class closer to reality. The limitation of this approach is the equity and accessibility to technology. Future work is to create e-learning groups on Facebook, share specific or additional content, and discuss online forums.

Acknowledgment

The author would like to thank Dr. Pannee Boonprakob and Mrs. Parichat Puangmanee for their comments, insightful suggestions, a careful reading of the manuscript, and thanks GLOBE Thailand for learning resources supporting. My thanks are also extended to Dr. Sri Adi Widodo, M. Pd., Department of Mathematics Education, Universitas Sarjanawiyata Taman Siswa Yogyakarta, for his advice and assistance in doing the meteorological data analysis.

References

[1] Katewongsa, P., Widyastaria, D. A., Saonuam, P., Haematulin, N., & Wongsingha, N. (2020). The effects of the COVID-19 pandemic on the physical activity of the Thai population: Evidence from Thailand's Surveillance on Physical Activity 2020. *J. Sport Heal. Sci* 10(3):341-348. doi: 10.1016/j.jshs.2020.10.001..

[2] Irfan, M., Kusumaningrum, B., Yulia, Y., & Widodo, S. A.et.all. (2020). Challenges During the Pandemic: Use of E-Learning in Mathematics Learning in Higher Education. *Infinity. Journal.* **9 (2):** 147

[3] Grover, S., Goyal, S. K., Mehra, A., Sahoo, S., & Goyal, S. (2020). A Survey of Parents of Children Attending the Online Classes During the Ongoing COVID-19 *Indian J Pediatr 88, 280 (2021). https://doi.org/10.1007/s12098-020-03523-5.*

[4] Laprairie, K. N., & Hinson, J. M. (2006). When Disaster Strikes, Move Your School Online *J. Educ. Technol. Syst.* **35** 209–14

[5] Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis *J. Educ. Technol. Syst.* 49 (I), 5–22.

[6] Adnan, M., & Anwar, K. (2020). Online Learning amid the COVID-19 Pandemic: Students' Perspectives. *Online Submiss.* 2, 45–51

[7] Revell, A., & Wainwright, E. (2009). What Makes Lectures 'Unmissable'? Insights into Teaching Excellence and Active Learning. *J. Geogr. High. Educ.* **33** (2), 209–230. https://doi.org/10.1080/03098260802276771

[8] Michel, H. (2016). Characterizing Serious Games Implementation's Strategies: Is Higher Education the New Playground of Serious Games? *49th Hawaii International Conference on System Sciences (HICSS)* (IEEE) pp 818–26.

[9] Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, Motivation, and Learning: A Research and Practice Model *Simul. Gaming*, 33 (4), 441–467. http://dx.doi.org/10.1177/1046878102238607

[10] Silius K, Miilumäki T, Huhtamäki J, Tebest T, Meriläinen J and

Pohjolainen S 2010 Social media enhanced studying and learning in higher education *IEEE EDUCON 2010 Conference* pp 137–43
[11] Tess, P. A. (2013). The role of social media in higher education classes (real and virtual) - A literature review.*Comput. Hum. Behav,* 29 (5). A60 – A68.
[12] Karpinski, A. C., Kirschner, P. A., Ozer, I., Mellott, J. A., & Ochwo, P. (2013). An exploration of social networking site use, multitasking, and academic performance among United States and European university students *Comput. Human Behav*, 29, 1182–1192.
[13] Khatoon, M., & Banu, A. (2015). A Survey on Community Detection Methods in Social Networks *Int. J. Educ. Manag. Eng,* 1, 8–18.
[14] Kabilan, M. K., Ahmad, N. & Abidin, M. J. Z. (2010). Facebook: An online environment for learning of English in institutions of higher education? *Internet High. Educ,* 13 (4), 179–187.
[15] Al-Mashaqbeh, I. F. (2015). Facebook applications to promote academic engagement: Student's attitudes towards the use of Facebook as a learning tool. *I.J. Modern Education and Computer Science*, 2015, 11, 60-66.
[16] Ministry of Education. (2001). *Basic Education Curriculum B.E. 2551*
[17] Creswell, J. W. (2002) Educational research: Planning, conducting, and evaluating quantitative. New Jerse: Prentice Hall Upper Saddle River.
[18] Akour, M., Alsghaier, H., & Aldiabat, S. (2018). Game Based Learning Approach to Improve Self-Learning Motivated Students *Int. J. Technol. Enhanc. Learn,* 12 (2). . *http://dx.doi.org/10.1504/IJTEL.2020.10027116*
[19] O' Dwyer, A., Hamilton, M., & Bowles R 2020 Learning with and from Others: Self-Study of Teacher Education within a Landscape of Practice. *Stud. Teach. Educ,* **16** 364–384.
[20] Richardson, J. C., & Newby, T. (2006). The Role of Students' Cognitive Engagement in Online Learning *Am. J. Distance Educ,* **20** 23–37. https://doi.org/10.1207/s15389286ajde2001_3
[21] Basham, J. D., Stahl, W., Ortiz, K. R., Rice, M. F., & Smith, S. J. (2015). Equity matters: Digital and online learning for students with disabilities. KS: Center on Online Learning and Students with Disabilities.
[22] Pearson E J and Koppi T 2002 Inclusion and online learning opportunities: designing for accessibility. *Research in Learning Technology*, 10 (2), 17–28. https://doi.org/10.3402/rlt.v10i2.11398

2021
SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 1, No: 2, PP:28-34
www.journal.qitepinscience.org
Research Paper
Open Access

Discovery Learning Assisted E-Learning to Improve Student Conceptual Understanding About Heat and Its Application

Zainul Mustofa[1]

[1]*SMK Al Munawwariyyah, Zainulmustofa26@guru.smk.belajar.id.*

Abstract

Synchronizing the concepts of heat and heat transfer explicitly on the competency of expertise in vocational schools still needs further research. This research focuses on the impact of discovery learning assisted by e-learning in improving student understanding about the concept of heat, its transfer, and its application. Through the one-group, pre-test – post-test design with 36 subjects of computer and network engineering students, Al Munawwariyyah Vocational School, this research was applied. The results showed an increase in conceptual understanding with n-gain values of 0.79 (high) and a d-effect size of 3.01 (very high). This value indicates that discovery learning assisted by e-learning has a positive impact on increasing students' conceptual understanding from an average pre-test of 39.9 to an average post-test of 84.1. Students' skills in troubleshooting the Central Processing Unit (CPU) problems increase significantly after learning. Most students can explain the heat transfer by conduction, convection, and radiation that occurs on the CPU along with the impact and benefits of competency expertise.

Keywords: Discovery learning, E-Learning, Conceptual Understanding, Heat and Transfer

Introduction

The rapid development of technology has brought various changes in various sectors, including the education sector. The monotonous teaching model with the lecture system is no longer in its era to be applied. There has been a massive shift from teacher-centred learning patterns to student-centred as the main characteristic. This is evidenced by the increasingly widespread, applications supporting the assessment of learning in the classroom and outside the classroom, such as Quizizz (Nanda et al., 2018), Kahoot (Rafnis, 2018), Plickers (Yulanda & Zafri, 2019), and other applications. In addition to assessment-based supporting applications, there is also Learning Management System (LMS) application such as Moodle (Mustofa, 2019) and virtual home learning classes (Waskita, 2019) owned by Centre for Data and Information (Pusdatin), Ministry of Education, Culture, Research, and Technology of Indonesia.

Various developments in education-based applications have brought significant changes in improving the quality of learning. This nuance gave rise to various learning innovations that were quite diverse. Some of them involve interactive multimedia such as PhET and interactive PowerPoints (Mustofa, 2016; Mustofa, 2018), online-based assessment, to distance learning such as MOCC (massive open online course) (Ismail et al., 2018) as applied in developed countries.

On the other hand, vocational education has greater challenges than just integrating learning with information technology. This is because vocational education at the secondary level has competency standards for graduates (SKL) that are different from secondary education in general. In accordance with Ministerial of Education and Culture regulation No. 34 Year 2018 (Permendikbud No. 34/2018), the purpose of this level of education is to master science and technology and have productive abilities according to their competency. This means students need to be facilitated to not only understand globalization and its changes, but also the concepts of knowledge that link and match with the competencies of their expertise. Hopefully after they graduate, they can be filtered into the world of work in accordance with their competence.

Physics as the basic subject in the field of competence has an irreplaceable role in supporting the achievement of competencies in engineering majors to balance theory and practice. Computer and network engineering majors are closely related to physics. This is in accordance with National Work Competence Standard (SKKNI 2016-285, Ministry of Manpower, 2016) which states that one of the competencies that must be mastered by graduates of this department is the ability to check CPU processor coolers. This expertise is not only related to practice but more specifically explained that students must understand the various processes that support the cooling system. In physics, related studies are explained in the concept of heat and transfer. Collaboration between basic computer science and physics is necessary. According to Santoso (2015), the procedure of installing a cooling fan in a precise position is very important, because it is closely related to efforts to maintain a stable processor temperature by flowing heat through the system.

Exposing the importance of heat material and its transfer does not seem to be followed by a good understanding of the concept of heat in general. This is consistent with reports from various journals stating that most students experience misconceptions in explaining the concept of heat and its transfer (Kartal et al., 2011; Alwan, 2011; Soeharto et al., 2019). Misconceptions like this should not happen especially to students, because the wrong concept will have fatal consequences in the practice of their expertise.

Based on these problems, a related solution is necessary. Surely the solution taken must be nuanced learning according to the era, that is based on information technology and the cultivation of appropriate concepts that can be collaborated with expertise. One learning that can facilitate these needs is discovery learning. Discovery learning is a learning model that emphasizes the discovery of basic concepts (Wenning, 2011). E-learning is an internet-based or intranet vehicle that is useful for facilitating more interactive learning (El-Seoud et al., 2014).

Based on the explanation of these advantages, this research focuses on the application of discovery learning assisted by e-learning. The aim is to find out how far the effect of discovery learning assisted by e-learning can improve the understanding of the concept of heat, its transfer, and its application in the field of computer engineering in physics subject.

Methods: Research Design

This study used pre-experimental research. It applied a one-group pre-test – post-test design (Gall et al., 2003). The subjects of the study were 36 students of class X Computer and Network Engineering (TKJ) Academic Year 2018/2019, Al Munawwariyyah Vocational School, Bululawang, Malang Regency.

In accordance with the research plan, this study consisted of two stages, namely learning design and learning implementation. The learning design focused on analysing the material needs of students majoring in computer and network engineering as well as the preparation of e-learning media as a support for discovery learning. Material requirements analysis was adjusted to SKKNI published by the Indonesian Manpower Office and Physics Curriculum for Vocational Computer and Network Engineering. Specifically, this research focuses on the heat and transfer material which is useful in understanding the processor cooling system and heat flow inside the CPU which is very beneficial for increasing student skills.

The preparation of e-learning media as a discovery learning platform was prepared by the teacher independently. This media was developed from Moodle managed by a LAN network (only accessible in a school environment). This was adjusted to the conditions and school rules in the boarding school environment but still facilitates learning based on controlled information technology.

The next activity was making Lesson Plan according to KI 3 and KI 4. The lesson plan was developed with discovery learning models assisted by e-learning media. Practice-based learning activities were carried out in the classroom and the Computer Disassembly Laboratory (CDL), while discussion activities, questions and answers, and materials were integrated with e-learning in the classroom that can be accessed only in the school environment. Through these e-learning activities such as assessment of learning (formative), discussion forums, questions and answers, and data sharing can be done freely and controlled.

After the planning was complete, the results of the design were implemented in learning. This stage consisted of three parts, namely pre-test (initial understanding test), implementation of the learning plan, and post-test (final understanding test). Pre-test and post-test questions were used to measure the understanding of the concept of heat and its transfer. Pre-test and post-test instruments consisted of 14 multiple-choice questions. The instrument was validated by 61 students who had studied the material temperature and heat. The results stated that the instrument is valid and reliable with a reliability coefficient of 0.79 which is included in the reliable category. This means that the instrument on the understanding of concepts is ready to be used to measure validly and consistently.

Data analysis related to the implementation of the design was carried out quantitatively and qualitatively. Pre-test and post-test results were quantitative data and analysed using descriptive statistical tests and followed by paired t-tests to find out whether there are differences between the students' understanding of concepts before and after treatment. Furthermore, further analysis using the average N-gain and effect size were carried out to find out how much it affects to students' understanding toward the concepts. Qualitative analysis was carried out using observation and documentation techniques to reinforce the results of the quantitative analysis conducted primarily concerning students' skills in applying the concept of heat and its transfer in the computer field. Through observation also, students' difficulties related to the concept of heat and transfer can be resolved during learning process. It can be explored more to support quantitative data obtained from the results of the post-test.

Findings and Discussion

Increased Understanding of the Concept of Heat and Transfer

The results of the pre-test and post-test had done in descriptive statistical analysis. The results of the analysis are presented in Table 1. It shows that the average post-test (84.1) is higher than the pre-test value (39.9). Based on the skewness value of the two groups of data, the values are between -1 and 1, meaning that the data are normally distributed so that the different tests can be performed using parametric analysis (Morgan et al., 2004). Through the paired-sample t-test, a significance value of p = 0,000 was obtained. These results indicate that there are significant differences between the post-test and the pre-test significantly. Calculation of the average n-gain obtained 0.79 which included in the medium-high category (Hake, 1998; Mustofa & Asmichatin, 2018). This means that discovery learning assisted by e-learning can significantly improve students' understanding of the concepts in heat material and its transfer and application. Effect size calculation results obtained valued d= 3.01 in the category of very high. This means that discovery learning assisted by e-learning has a very positive effect on the understanding of the concept of heat and its transfer to computer and network engineering students.

Aspect	Pre-test	Post-test
N	36	36
Average	39,9	84,1
Minimum	7,1	42,8
Maximum	71,4	100
Std. Dev	14,18	15,19
Skewness	-0,135	-0,844

Table 1. The Result of Statistic Descriptive Analysis

Improving students' understanding of concepts causes students to be actively involved. They are invited to find out the concept of a phenomenon or problem that they encounter. They were also invited to find problems, predict signs of problems, and find solutions based on these signs. According to Jean Piaget's theory of cognitive development, learning that facilitates students to find concepts independently can trigger the development of their schemata. Triggering the development of this schemata can produce a new balance that is more mature so that the concepts possessed are stronger (Slavin, 2006). The results of this study support several studies stating that discovery learning assisted by e-learning can improve students' understanding of concepts. Mustofa (2019) found that discovery learning that is integrated with e-learning media can improve students' understanding of concepts in solution concentration and its application material. Through this learning as well, the ability of students' scientific literacy increases so that the quality of concepts mastered by students becomes like the experts.

Students' Skills in Applying the Concept of Heat and Its Transfer in Computer Science

Students' skills in applying this concept can be accessed during learning and after learning process ends. At the practical session on the material of heat and its transfer, each group of students was asked to disassemble the computer and analyse the CPU cooling system. Besides, students were asked to test the effect of pasta processors with different prices on the ability to transfer heat to maintain a stable processor temperature when working in both standby and heavy work conditions such as rendering videos and playing games.

Student activities while in the laboratory could be seen in Figure 1. Students per group were given one computer and a set of assembled and disassembled computers to clean the inside of the CPU. After finishing cleaning and observing the CPU cooling system, then students were asked to reassemble. After testing, it turns out there was one group reporting that the computer suddenly shut down when turned on. Learning heat transfer begins with giving problems in the scope of the computer that is when the initial button on the CPU is turned on suddenly the computer off by itself. Armed with troubleshooting material, some students gave responses, ranging from problematic power supplies, hard drives that did not fit into their positions, hot processors, applications that did not support, resulting in the death of the computer itself.

The teacher did not answer directly to the problems. Then the teacher instructed students to disassemble the CPU again and looked for the cause of the problem. They found that the cooling fan did not turn on and the heatsink was not tight, resulting in the processor became hot.

Figure 1. Practical Disassemble CPU

The findings of existing problems were reported in front of the class. The results are emphasized by the group of students experiencing problems and explained various causes. After the discussion in class, it was concluded that one of the causes was the shutdown of the cooling system. Therefore, all students understand the science of troubleshooting a problem related to computers. Not quite so, the teacher continues to invite students to test the ability of a cheap and expensive pasta processor. They were asked to test the difference between the quality of the two ingredients in transferring heat from the processor to the heatsink to keep the processor temperature stable. One of the students' activities in the second practicum was shown in Figure 1 (left). The result is that the quality of the expensive pasta processor has a better heat transfer capability in maintaining processor temperature both during standby, normal use, and heavy use such as when playing games or rendering the video.

After learning is finished, the teacher provided a post-test. Based on the results of the post-test, most students can answer the questions related to heat and transfer applied to the computer.

Perhatikan gambar sirkulasi udara dalam CPU berikut ini

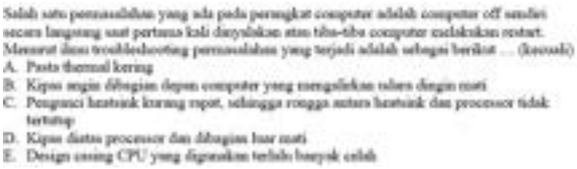
Berdasarkan konsep aliran udara tersebut, panas akan berpindah secara .... yang dipengaruhi beberapa factor antara lain suhu di luar CPU. Apabila suhu di luar CPU lebih dingin (Ruangan Ber-AC) maka, suhu CPU akan cenderung ... sehingga kondisi CPU relative lebih stabil.

A. Konduksi, rendah
B. Konduksi, tinggi
C. Konveksi, rendah
D. Konveksi, tinggi
E. Radiasi, tinggi

Figure 2. Problem to access the concept of heat transfer

The problem to access student understanding related to heat transfer that occurs on the computer is presented in Figure 2. Based on the results of students' answers at the post-test, it was found that there were 28 students out of 36 students (77.8%) able to answer correctly. This means that most students understand correctly that the concept of heat flow is heat transfer by convection from the system to the environment. This understanding indirectly influences the mindset of students related to the system and environment in explaining the concept of energy flow as discussed by Mustofa & Asmichatin (2018). While other factors that can affect CPU performance are room or place factors. With this kind of understanding, students are expected to have an idea of how to prepare for computer installation while working in the future.

Questions to access how the concept of heat and transfer can support the competency abilities of their expertise are presented in Figure 3. Through these problems, students were asked to analyse various problems. This is closely related to the science of troubleshooting that is practically learned in competency subjects. Based on the results of the post-test, it was found that there were 32 out of 36 students who answered correctly. Based on the results of a hypothetical analysis such as done by Mustofa (2018) when making a choice shows that a large number of students are already able to master the concept of heat applied in the computer field with the following explanation: (1) they do not choose option (A), meaning they assume that if the thermal paste is dry, the ability to conduct heat conduction from the processor to the heatsink is not optimal, so the processor temperature tends to be less stable or hot; (2) They do not answer option B, which means that practically they understand the concept of convection heat flow on the CPU so that the temperature inside the CPU remains stable; (3) They do not choose options C and D, which means they have two abilities, namely first understanding that the installation must be thorough, and secondly, they understand that the air cavity is not a good conductor for rapid transfer of heat from the processor to the heatsink.


Salah satu permasalahan yang ada pada perangkat computer adalah computer off sendiri secara langsung saat pertama kali dinyalakan atau tiba-tiba computer melakukan restart. Menurut ilmu troubleshooting permasalahan yang terjadi adalah sebagai berikut … (kecuali)

A. Pasta thermal kering
B. Kipas angin dibagian depan computer yang mengalirkan udara dengan mati
C. Pengunci heatsink kurang rapat, sehingga rongga antara heatsink dan processor tidak tertutup
D. Kipas diatas processor dan dibagian luar mati
E. Design casing CPU yang digunakan terlalu banyak celah

Figure 3. Problem to access the synchronization of physics and science troubleshooting

Conclusions and Sugestions

Based on the discussion, it can be concluded that discovery learning assisted by e-learning can improve the understanding of the concept of heat and its transfer. Through this learning, the improvement of students' conceptual understanding is obtained high, with an n-gain of 0.79 and a d-effect size of 3.09 which shows that learning has a very positive effect on students' conceptual understanding. Through this learning as well, students' skills in troubleshooting computer problems related to the concept of heat and transfer increase. Most students can explain in detail the effects and benefits of heat transfer by conduction, convection, and radiation that occur on the CPU that supports the competence of their expertise. The success of discovery learning assisted by e-learning can be an option for further research with different materials.

References

Alwan, A. A. (2011). The misconception of heat and temperature Among Physics students. Procedia Social and Behavioral Sciences 12, 600-614.

El-Seoud, M. S., Taj-Eddin, I. A., & Seddiek, N. (2014). E-Learning and Students' Motivation: A Research Study on the Effect of E-Learning on Higher Education. iJET 9 (4), 20-26.

Gall, M. D., Gall, J. P., & Borg, W. R. (2003). Educational Research: An Introduction 7th. United States: Pearson Education, Inc.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics 55(5), 455-462.

Ismail, M. E., Utami, P., Ismail, I. M., Hamzah, N., & Harun, H. (2018). Development of Massive Open Online Course (MOOC) Based on Addie Model for Catering Courses. Jurnal Pendidikan Vokasi 8 (2), 184-192.

Kartal, T., Ozturk, N., & Yalvac, H. G. (2011). Misconceptions of science teacher candidates about heat and temperature. Procedia Social and Behavioral Sciences 15 , 2758-2763.

Kemnaker. (2016). Penetapan Standar Kompetensi Kerja Nasional Indonesia Kategori Informasi dan Komunikasi Golongan Pokok Aktivitas Pemrograman,Konsultasi Komputer dan Kegiatan yang Berhubungan dengan itu (YBDI) Bidang Computer Technical Support. Jakarta: Kementerian Ketenagakerjaan Republik Indonesia.

Mendikbud. (2018). Standar Kompetensi Lulusan SMK. Jakarta: Kementrian Pendidikan dan Kebudayaan.

Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barrett, K. C. (2004). SPSS for Introductory Statistics: Use and Interpretation (Second Edition). New Jersey: Lawrence Erlbaum Associates.

Mustofa, Z. (2016). Penerapan Pembelajaran STAD Berbantuan Multimedia untuk Meningkatkan Keaktifan dan Penguasaan Konsep Usaha-Energi. Seminar Nasional Jurusan Fisika (pp. 643-647). Malang: FMIPA UM.

Mustofa, Z. (2018). Pengaruh Multimedia Interaktif dalam Pembelajaran Remedial untuk Meningkatkan Prestasi Belajar Fisika. Jurnal Teknodik 22 (2), 121-132.

Mustofa, Z. (2018). The Description of Student Understanding About Elasticity Concept. Jurnal Penelitian dan Pengembangan Pendidikan Fisika 4 (1), 27-34.

Mustofa, Z. (2019). Panduan Membangun E-Learning di Kelas. Jombang: Kun Fayakun.

Mustofa, Z. (2019). Pengaruh Discovery Learning Berbantuan E-Learning dalam Meningkatkan Penguasaan Konsep Siswa Tentang Konsentrasi Larutan dan Aplikasinya. Kwangsan 7 (1), 15-29.

Mustofa, Z., & Asmichatin, A. (2018). Modeling Instruction to Promote Student's Understanding of System and Model of System of Mechanical Energy. Abjadia: International Journal of Education 3 (1), 17-29.

Nanda, S. R., Abdul, N. B., & Daddi, H. (2018). The Use of Quizizz Application in Improving Students' Reading Comprehension Skill at SMKN 3 Takalar. Journal of Computer Interaction in Education (JCIE) 1 (2), 173-182.

Rafnis. (2018). Pemanfaatan Platform Kahoot Sebagai Media Pembelajaran Interaktif. Jurnal Ilmiah Teknologi Pendidikan 6 (2).

Santoso, R. (2015). Troubleshooting Perangkat Keras Komputer. Malang: Grup Pembelajaran Insan Komputer (GPInkom).

Slavin, R. E. (2006). Educational Psychology: theory and practice (8th ed). Boston: Pearson/Allyn & Bacon.

Soeharto, Csapo, B., Sarimanah, E., Dewi, F., & Sabri, T. (2019). A Review of Students' Common Misconceptions in Science and Their Diagnostic Assessment Tools. Jurnal Pendidikan IPA Indonesia 8 (2), 247-266.

Waskita, B. (2019). Pemanfaatan Portal Rumah Belajar untuk Meningkatkan Kualitas Pembelajaran. Jurnal Teknodik, 65-78.

Wenning, C. J. (2011). The Levels of Inquiry Model of Science Teaching. J. Phys. Tchr. Educ. Online 6 (2), 9-16.

Yulanda, L., & Zafri. (2019). Pemanfaatan Aplikasi Plickers Pada Mata Pelajaran Sejarah Kelas X SMAN 01 IV Nagari Bayang Utara. Jurnal Kapita Selekta Geografi, 54-77.

2021

SciEd

SEAQIS Journal of Science Education

SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 1, No: 2, PP:35-48
www.journal.qitepinscience.org

Research Paper Open Access

Improving the Science Process Skills of Science, Technology, Engineering Students through Personality-Based Approach

Leo Peter Dacumos[1]

[1] *Special Science Teacher IV, Philippine Science High School – Cordillera Administrative Region Campus*

Abstract

The study aimed to investigate the impact of the Personality-based Approach (PBA) on the integrated science process skills (SPS) of grade 7 Science, Technology, and Engineering (STE) students as compared to the conventional learning approach. A two-grouped quasi-experimental design with pretest and posttest was used in this study. This method consisted of two instructional groups (control group in conventional learning approach and experimental group in Personality-based Approach), and repeated testing (pretest and posttest) on students' science process skill competency level. Results showed Grade 7 students of Baguio City National Science High School have an overall performance exceeding average achievement. Individually, the experimental group who was given the personality-based approach (PBA) performed high with their science process skills while the control group which was given with the conventional approach had typical science process skill levels. When compared, the experimental group have better performance in the skills where students are to prepare research proposals than their counterpart in the control group. However, in terms of the experimentation process down to creating models, the two groups do not differ.

Keywords: personality-based approach, personality styles, science process skills, academic performance, differentiated instruction

Introduction

Science as a subject deals with almost everything in the environment (Supriyatman and Sukarno, 2014). It is a course that is mandated from junior to senior high school to equip students with knowledge about nature. Hence, students are expected to have the ability to observe, infer, predict, communicate, hypothesize, experiment and implement concepts towards the protection of natural resources. This, therefore, entails that the success of science learning is measured through the abovementioned abilities (Karamustafaoglu, 2011) which will collectively determine the students' level of Science Process Skills (SPS).

Scientific process skills (SPS) include skills that every individual could use in each step of his/her daily life by being scientifically literate and increasing the quality and standard of life by comprehending the nature of science (Aktamis and Ergin, 2008). Therefore, these skills affect the personal, social, and global lives of individuals. The SPS are a necessary tool to produce and use scientific information, to perform scientific research, and to solve problems – skills that Science, Technology, Engineering and Mathematics (STEM) students need before they go for higher sciences at the tertiary level.

According to Supriyatman and Sukarno (2014), learning science should provide the opportunity for students to develop science process skills (SPS). The educational system should provide learners with the opportunity to develop the science process skills to enable their creativity, which is essentially necessary to search for solutions (Aktamis and Ergin, 2008) to all kinds of problems that are encountered in daily life and to make new products, creating, therefore, future engineers, scientists, mathematics and health care force for the country. Many studies show that creativity can make their science education functional, and therefore, scientific information can be the basis for producing a valuable product instead of just amassing information.

However, deficiency of educational facilities (Salem al-amarat, 2011) and instructional materials (Ogbu, 2015), large class size (Eison, 2010), poor instruction (Eison, 2010), and non-differentiated instructional methodologies and curriculum (Weselby, 2014) are problems that threaten education process and students ability to develop their science process skills. The current educational system of the Philippines is filled with problems on classrooms shortage and scarce funding to provide for differentiated instructional materials required in each science classroom. These are pressing problems that impede teaching and learning to succeed. Due to these predicaments, the successful teaching process is encumbered and, in turn, achievement in learning is not met. Many students are not able to cope with these problems hence can result in their poor performance in achieving science process skills.

Differentiating instructional methodologies, curriculum and materials are ways to alleviate the problem abovementioned. Differentiated instruction "is the practice of modifying and adapting instruction, materials, content, student projects and products, and assessment to meet the learning needs of individual students (Tucker, 2011)." Differentiated instruction excites the brilliant student to uncover deeper layers of learning, while simultaneously structuring curriculum to support lower-level students or students with learning disabilities- both identified and unidentified, in turn, increasing their ability to master their science process skills.

It is without any doubt that intelligence, as proven by research, predicts the academic performance of students. However, various studies show that there are also non-cognitive factors that are responsible for students' academic performance.

Ciorbea and Pasarica (2013) discussed that personality is now an important consideration that affects students' academic performance. Performance of the students in science enhances when activities are specific to their type of personality, i.e. one who is introverted gets an activity that is geared towards autonomous learning while extroverted students perform better in collaborative activities. Previous research shows that a significant relationship between students' personality styles and their academic achievement exists (Dacumos, 2016). Jang et al (2016) concur with this finding indicating that academic achievement is significantly related to the student's personality style in sensing-intuition and judging-perceiving preferences. Furthermore, they say that knowing students personality styles will be helpful in the selection of appropriate teaching and learning strategies to provide better education. Finally, Al-Naggar et al (2015) found out that openness and conscientiousness personalities were found to be positively associated with academic performance.

Considering these findings, one can say that a way to differentiate instruction is by considering their personality styles. There is a close relationship between personality styles and students' academic achievement in science (Dacumos, 2016). Findings showed that students with introverted personalities perform better in the autonomous way of learning while extroverted students have better performance when activities are conducted in a group (Dacumos, 2016). It is, therefore, imperative that educators throughout the world should be inclined in differentiating the learners as to their personality style by dichotomizing the materials specialized for these varied psychological differences.

Many of the above studies only focused on determining the relationship between the academic performances of the students. These studies failed to demonstrate the effectiveness of differentiated instruction or assessment patterned according to the learners' personality styles.

This study aimed, therefore, to test whether using a differentiated formative assessment which is designed to the specific students' personality styles can improve their basic Science Process Skills. This approach is called the Personality-based Approach (PBA). This is an approach designed by the researcher as an offshoot of the previous research which determined the significant relationship between the personality styles of the students and their academic performance (Dacumos, 2016). Through this approach, STE learners are expected to be equipped with the basic science process skills (SPS) necessary for their knowledge and skill acquisition of higher sciences and scientific investigation.

Research Questions

The study aimed to investigate the impact of the Personality-Based Approach (PBA) on the integrated science process skills (SPS) of grade 7 science, technology, and engineering (STE) students as compared to the conventional learning approach. Specifically, this study answered the following:

1) What is the Integrated Science Process Skills competence level of STE students along with the following domains?

a. Use of Scientific Knowledge

b. Formulation of Scientific Question

c. Designing of Experiment

d. Communication of Scientific Procedures

e. Collection of Data

f. Creation of Visual Representation

g. Organization of Data

h. Analysis of Data

i. Use of Nominal Scientific Knowledge to Communicate Results

j. Use of Models to Explain Results

k. Use of Results to Answer Question

2) Is there a significant difference between the SPS competence level of the experimental and the control group along with the SPS domains?

3) What intervention can be proposed to increase the Science Process Skills (SPS) competence level of the Grade 7 STE students?

Scope and Delimitation

A sample of 124 grade 7 students randomly selected from Baguio City National Science High School participated in the study and were assigned to either the experimental or control group. This study limits its coverage on the grade 7 students under the Science, Technology, and Engineering (STE) program and undergoing the introductory research subject, i.e. Research 1. The main purpose of the study was to investigate the effectiveness of the proposed Personality-based Approach (PBA) in the improvement of the science process skills of the students compared to the conventional learning approach. This is proposed as it is found that the declining academic performance of the students may be due to their low achievement of the science process skills resulting from an undifferentiated and intelligence-focused curriculum. Pre-post test scores described the Science Process Skills (SPS) competence level of the students and were likewise used to compare the two groups, however for the sake of discussion, only the post-test was used to give a statistical inference on the significant difference between the two approaches.

Research Methodology

A two-grouped quasi-experimental design with pretest and posttest was used in this study. This method consisted of two instructional groups (control group in conventional learning approach and experimental group in Personality-based Approach), and repeated testing (pretest and posttest) on students' science process skill competency level.

Participants/Data Source

A sample of 124 grade 7 students from Baguio City National Science High School (BCNSHS) – Science, Technology, and Engineering (STE) program participated in the study. The sample was computed from the online sample size calculator developed by Raosoft Inc., and respondents were chosen via random selection. A personality-based Approach (PBA) was performed for the experimental group (n=62), while a conventional learning approach was employed for the control group (n=62). The sample from the experimental group was further distributed according to their personality styles, i.e. introverts and extroverts. Their personality styles profile were determined by the designated guidance counsellor using the Personality Style Inventory (PSI) by Hogan and Champagne (1980). This division allowed the researcher to implement formative activities in Research 1 specific for introverted and extroverted students, i.e. self-learning activities for the introverted students and collaborative activities for the extroverted students. In the selection of respondents for this study, the following criteria should be met: they are currently enrolled in the Research 1 subject and have basic knowledge of science courses.

Data Gathering Procedure and Instruments

The variables in this research consisted of independent and dependent variables (Table 1). The personality-based Learning Approach (PBA) and conventional learning approach are the independent variable (X) for the study. The dependent variable (Y) is the level of science process skill of the grade 7 STE students.

To collect the data, Science Process Skill Inventory (SPSI) was used. The SPSI was developed by Arnold and Bourdeau (2009) to "measure the ability to practice the full cycle of steps in the scientific inquiry process. The inventory measures science process skills, not science content knowledge." Hence, this inventory is appropriate for measurement in scientific investigation that requires scientific skills while not focusing much on the science content. To secure permission for the use of this inventory, an e-mail was sent to Dr Mary Arnold of the College of Public Health and Human Sciences, Oregon State University on September 03, 2017. A response e-mail from Dr Arnold approving the request on the use of the SPSI was received on September 05, 2017.

Table 1. Variables of the Research

Sample	Treatment	Post-test
Experimental Group	X1	Y
Control Group	X2	Y

where Y: Post-test (Science Process Skill competency level after treatment)
X1: Treatment by using Personality-based Approach (PBA)
X2: Treatment by using Conventional Learning Approach

Psychometric testing for the SPSI: the Cronbach's Alpha calculated pre-program/post-program with middle schools students attending a two-week residential summer science camp in 2007 and 2008 at Oregon State University (n=106) revealed coefficients of .84 and .94, respectively. Split-half reliability (Spearman-Brown) was .93. Kaplan and Saccuz (1993) argue that instruments with a reliability coefficient of at least 0.7 are accepted as reliable in research.

The inventory consists of eleven items, each representing a different skill in the science inquiry process. Youth are prompted to respond to each statement using a 4-point Likert scale indicating how often they practice each of the items when doing science: Never (1), sometimes (2), usually (3), and always (4). Recommended scoring of the SPSI is the calculation of a composite science process skills score. This is calculated by summing the individual ratings for each item and getting its mean. The score (rating) range for the composite score is 11-44.

The SPSI measuring the basic SPS level of the students was given to both experimental and control groups before the treatment as a pre-test formatted in an online sharing platform for easy collection of data. Both groups were given varied teaching strategies in the implementation of the lesson in Research 1. The experimental group were given a formative assessment that adopted the Personality-based Approach (PBA) which the researcher personally designed to cater to the specific assessment requirement of students with varied personality styles. Introverted students received self-learning design formative assessments while extroverted students were formatively assessed with the cooperative-learning design of the assessment tool.

On the other hand, the control group received undifferentiated formative assessment tools in the implementation of topics in Genetics.

After the implementation, the basic Science Process Skills Inventory (SPSI) was used to assess the SPS level of the students and was recorded as a post-test. However, in the discussion of results, only the post-test results were used to assess the extent of effectiveness of the PBA vs the conventional approach which was given to the experimental and control groups, respectively.

To describe the SPS competence level of the grade 7 STE students on their science process skills, the following score and its interpretation were used is given in Table 2.

Table 2. SPS Mean and Interpretation on SPS competence level

Range	Interpretation (SPS Competence Level)
3.40 – 4.00	Excellent
2.80 – 3.39	Above Average
2.20 – 2.79	Average
1.60 – 2.19	Below Average
1.00 – 1.59	Very Poor

Data Analysis

Shapiro-Wilk test was used to test the normality of distribution of the respondents for the SPS scores of both the experimental and control groups. Tests revealed a *p*-value lower than the set alpha level at 0.05 ($p_{value} < \alpha_{0.05}$), indicating a skewed population. This means that the scores of the sample significantly deviate from the normal distribution, hence the use of alternative non-parametric tests to check on the significant difference between the control and experimental group. Mann-Whitney U-test was used to compare the scores of the experimental and control group. All tests were done at the 0.05 level of significance, and rejection was observed when the *p*-value is lower than the set level of significance.

Ethical Issues

Ethical measures were observed in the course of data collection. The researcher had a moral obligation to strictly consider the participants' rights who will be providing the knowledge of the study to be conducted (Streuber-Speziale & Carpenter, 2003).

A. Consent

Consent letters were sent to the parents of the students before the gathering of data. This informed them regarding the nature of the study and how much their involvement will be in the current study.

B. Confidentiality and Anonymity

Confidentiality means that no information that the participant divulges is made public or available to others for their consumption (Wiles, Crow, Heath & Charles, 2006). The anonymity of a person is protected by making it impossible to link aspects of data to a specific person. Confidentiality and anonymity were guaranteed by ensuring that data obtained were used in such a way that no other researchers nor readers know the source of the scores and other vital data that were provided. In this study, codes were used to properly arrange the scores that were obtained from the respondents.

C. The right to withdraw from the study

In this study, participants were informed that they may opt to withdraw from the study at any time if they wished to. This was done prior to their involvement or engagement in the study, before the experimentation proper (Oates, Kwiatkowski & Coulthard, 2009). This right was included in the consent letter that was sent to the chosen respondents.

D. Dissemination of Results

Results will be disseminated in the form of a report. This report will not expose the scores nor the weaknesses of the respondents but may recommend the implementation of the appropriate approach in improving their science process skills competence level.

The respondents were informed that the study may be submitted for possible publication in relevant journals in science education.

Results and Discussions

This part presents the gathered data, their analyses and interpretation. The results with their respective discussions are presented in two main parts. Part I concerns the Science Process Skills (SPS) level of Grade 7 Science, Technology, and Engineering (STE) students while part II describes the significant differences of these levels according to the learning approach applied to the groups.

Science Process Skills (SPS) Level of Grade 7 STE Students

The discussions that follow present the level of science process skills (SPS) of grade 7 STE students in terms of the key domains necessary for understanding their overall process skills.

Table 3. shows the mean of the 11 domains of science process skills distributed according to the approach given in teaching research. An overall average of 2.8636 was reported and is interpreted as above average. This means that Grade 7 students of Baguio City National Science High School have acquired enough skills to design and carry out experiments or in everyday life to find answers to questions. Furthermore, they use these skills that are used in daily lives to figure out everyday questions.

This implies that students require more training in terms of honing the skills that they will be using in orchestrating scientific investigations although sufficient skills have been acquired to perform scientific inquiry. Educations' emphasis on developing these skills to the Science, Technology, and Engineering (STE) students is important as it prepares the students into becoming future science and mathematics professionals, and by doing so, these science process skills should be taken as highly important. According to Zorlu and Zorlu (2017),
"because science process skills involve cognitive, intellectual, manual and social skills used to solve problems encountered in daily life that they are regarded as a tool which enables individuals to get the most out of their knowledge."

Table 3. Science Process Skills (SPS) Level of Grade 7 STE Students

SPS Domains	Control	Experimental
	x	x
1. Defining and Identifying Variables	2.5484	3.0161
2. Formulation of Scientific Question	2.7581	3.2419
3. Designing of Experiment	2.4677	2.8871
4. Communication of Scientific Procedure	2.3387	2.8065
5. Collection of Data	2.9194	2.9677
6. Organization of Data	2.5000	2.8871
7. Creation of Visual Representation	2.7258	3.3871
8. Analysis of Data	2.7903	3.0323
9. Conclusion/Problem Solving	3.2903	3.4516
10. Use of Models to Explain Results	2.5484	2.6935
11. Use of Nominal Scientific Knowledge to Communicate Results	2.8710	2.8710
Overall	**2.7053**	**3.0220**
Overall (for both groups)	**2.8636**	

Legend:

Range	***Interpretation***
3.40 – 4.00	*Excellent*
2.80 – 3.39	*Above Average*
2.20 – 2.79	*Average*
1.60 – 2.19	*Below Average*
1.00 – 1.59	*Very Poor*

Gultepe (2016) emphasized that one of the fundamental skills that science curricula should aim for the students to achieve is science process skills. Harlen (1999) cited by Gultepe (2016) underscored that the attainment of these skills is one of the most important goals of science education as these are the sets of skills used not only by science, and mathematics professionals but also by everyone, as they aim to be scientifically-literate. Students of science high schools have been cultivated by scientific literacy and science process skills through research classes. These two skills are hoped to develop the skills needed by students in the 21st century (Turiman, Omar, Daud and Osman, 2011). Hence, when scientific literacy and science process skills are considered by teachers and the curriculum to develop amongst science, technology, and engineering (STE) students, students will be guided with their career choices in the science and mathematics profession via the STE/STEM education.

It is also reported in the table that conclusion/problem solving was highest in both groups. This integrated science process skill is, without a doubt, the most important part of any scientific investigation as this part accomplishes the very goal of a scientific inquiry, i.e. to answer the question. This means the students have skills that allow them to take this final step in the scientific method. They have the skills to craft a conclusion as this gives a precise and direct answer to the very objectives of the study, emphasize the shortcomings of the research, and give suggestions for future study. Problem-solving, as another facet of this domain, has been found above-average alongside concluding skills. Many students of BCNSHS find the necessity to develop this skill as this skill provide them with the ability to look at situations from different points of perspective using critical and metacognitive skills.

This finding concurs with the study of Molefe, Stears, and Hobden (2016) which found that problem solving/critical thinking and interpreting (graphs and tables) have the highest overall ranking of SPS in terms of importance as perceived by the student teachers of South African teacher education institutions. Problem-solving particularly requires the development of critical thinking, both as part of life skills and as a concept of science education is enshrined by the Philippine education curricula. It is therefore justifiable that both kinds of research find problem-solving/conclusion as most important and hence highly developed amongst students. Problem-solving and concluding is a decision-making process that requires metacognition and critical thinking. Warnich and Meyer (2013) as cited by Molefe, Stears, and Hobden (2016) discussed that problem solving and critical thinking were ranked very highly for students "personal acquisition". When one has fully attained this science process skill, one does not only see a situation from a multitude of points of view but can think about an action plan and, in turn, determine the effectiveness of this set of actions in the resolution of the determined problem.

Designing of the experiment, and communication of scientific procedure were found to be least attained by students in the control group. This means students have not fully achieved the necessary skills on how to design an experiment in the sense that how the observations or measurements should be obtained to answer a query in a valid, efficient, and economical way. Furthermore, their inability to communicate this design is revealed to have not been completely attained as reported from the table.

Designing the experiment and communicating its layout, along with the plan for data analysis, are inseparable skills that students must develop to give comprehensive inferences of observations and measurements obtained from the experiment. According to Shalabh (n.d.), an experiment that is properly designed while taking note of the question will yield valid data, and its proper analysis will provide valid statistical inferences. Hanson (n.d.) further emphasized that a "carefully" designed experiment will allow researchers to infer causation. Planning an experiment properly, indeed, is very important to ensure that the right type of data and sufficient sample size and power are available to answer the research questions of interest as clearly and efficiently as possible.

Likewise, science communication should be highly underscored as well. According to Mojer (2015), "science communication is part of a scientist's everyday life. Scientists must give talks, write papers and proposals, communicate with a variety of audiences, and educate others". It can be inferred therefore that in order to be successful, scientists and researchers, alike, should learn how to communicate not only their statistical inferences and implication from their conducted experiment but as early as during the proposal of their intended experimentation. Effective communication is a prerequisite skill to becoming a successful scientist. Mojer (2015) further asserts that "when scientists communicate more effectively, science thrives". The increasing development of science as it becomes more interdisciplinary requires its ability to be communicated across related disciplines that promote innovation and development.

On the other hand, the use of models to explain results was found to have rated very low in both groups. In science, a model is

> …representation of an idea, an object or even a process or a system that is used to describe and explain phenomena that cannot be experienced directly. Models are central to what scientists do, both in their research as well as when communicating their explanations. (Science Learning Hub, 2011)

This means students of BCNSHS have not fully developed their skills in coming up with a model generated from the data and results/findings of their conducted experiment. This may be due to the fact that developing models is one of the hardest skills to attain. According to CPD for teachers (2018), scientific theories and models are only valid as long as they can explain all of the available data, i.e. from both observations and measurements. Therefore, the strengths and limitations of the model must be evaluated as new data are obtained.

Scientists will often test out theories by carefully designing and carrying out experiments. If new data appear that do not fit the theory, then the theory may need to be modified and updated. It will then have to be tested out again to confirm the result. The data collected must be both repeatable and reliable. Sometimes it takes a while for other scientists to accept these new models. This implies, therefore, the need for teachers to improve their strategy in increasing the ability of the students to generate a model out of their data to explain the answers to the objective of their study as this does not only pertains to yield to a model that can easily be modified, but a model that is can be used to explain a phenomenon, and be adept to changes when modifications are necessary.

The difference in the SPS Level between Experimental and Control Group

The following discussions display the difference in the levels of the integrated science process skills (SPS) between the experimental, who was given the personality-based learning approach, and the control group, with the conventional learning approach, along with the specific domains.

Table 4. presents the associated *p*-values in the assessment of the significance of the differences in the science process skills (SPS) levels of the 11 specific domains between the experimental and control group using the Mann-Whitney U test of significance.

Mann-Whitney U test of significance reveals that six (6) domains, namely, "use of scientific knowledge", "formulation of scientific question", "designing of experiment", "communication of scientific procedure", "creation of visual representation", and "organization of data" have *p*-values lower than the alpha level set at 0.05 ($p_{value} < \alpha_{0.05}$). This rejects the null hypothesis which states that there is no significant difference between the experimental and control groups along with these six domains of the integrated science process skills (SPS). This indicates that in these domains, the experimental group who was given the personality-based learning approach have significantly improved these skills as compared to their counterpart in the control group which were given a conventional learning approach.

Table 4. Associated p-values in the Assessment of the Significance of the Differences in the Science Process Skills (SPS) Levels of the following Domains between Experimental and Control Group

SPS Domains	***p*-value**	**Decision**
Use of Scientific Knowledge	<0.001**	**Significant**
Formulation of Scientific Question	<0.001**	**Significant**
Designing of Experiment	0.002**	**Significant**
Communication of Scientific Procedure	<0.001**	**Significant**
Collection of Data	0.636	Not Significant
Creation of Visual Representation	<0.001**	**Significant**
Organization of Data	0.003**	**Significant**
Analysis of Data	0.059	Not Significant
Use of Nominal Scientific Knowledge to Communicate Results	0.977	Not Significant
Use of Models to Explain Results	0.271	Not Significant
Use of Results to Answer Question	0.189	Not Significant

*** significant at 0.01 level*

This implies that along with these domains, students when grouped according to their personality can improve significantly these skills to become researchers or students capable of scientific inquiry. It is more effective that students are dichotomized as to introversion and extroversion and that activities are specific to these personality styles. It should be remembered that introversion received activities which are basically self-learning or autonomous learning while those classified as extroversion were given with collaborative learning activities.

This gives a substantiation with the previous study conducted by the researcher that correlation exists between the personality styles of the students and their academic performance (Dacumos, 2015). While the former study correlates the cognitive aspect of learning science, i.e. their academic performance in science, the former study proves that considering the personality styles, as an additional consideration to holistically address the unique needs of the students, is likewise important in enhancing the skills of the students especially in the field of scientific inquiry and investigation. Furthermore, this proves that considering personality styles is as important as considering learning styles, and cognitive types of the students in planning for instructional strategies.

It is thus important for teachers to consider this facet of the learners to properly assist their individualized needs. According to Kennedy and Herring (2016), "information concerning the influence of personality on learning and teaching styles is important for industrial/organizational training programs just as it is in the educational classroom". Many kinds of research have already proved that people have an innate personality, unchangeable by time. Therefore, when information regarding personality styles is considered, this facilitates teachers and educators to properly and determinedly select the necessary type in approaching different situations such as selecting the proper educational teaching strategy that they will incorporate in their classroom instruction.

Differentiated instruction is thus an important key towards the achievement of such science process skills. Tucker (2011) defines this as "the practice of modifying and adapting instruction, materials, content, student projects and products, and assessment to meet the learning needs of individual students". It is earlier cited that differentiated instruction excites the brilliant student to uncover deeper layers of learning, while simultaneously structuring curriculum to support lower-level students or students with learning disabilities- both identified and unidentified, in turn, increasing their ability to master their science process skills.

It can be deduced further that these learners have a significant increase in the science process skills along the "proposal part" of the science process skill, i.e. to use scientific knowledge, to formulate the question, and to design and communicate scientific experiment procedure. This part of research is best highlighted as research proposals are "informative and persuasive writing because they attempt to convince the reader to do something. The goal of the student is not only to persuade the reader to do what is being requested but also to make the reader believe that the solution is practical and appropriate." (Zouaoui, n.d.). This study successfully increased the skills of the students in terms of identifying the problem and planning for an experimental design to give resolution to this cited problem. The personality-based approach (PBA) is effective in improving the said skills of the students of Baguio City National Science High School.

To highlight, taking into consideration other facets of students is important in order to yield better performance. Ciorbea and Pasarica (2013) discussed that personality is now an important consideration that affects students' academic performance. Performance of the students in science enhances when activities are specific to their type of personality, i.e. one who is introverted gets an activity that is geared towards autonomous learning while extroverted students perform better in collaborative activities.

Research further shows that when comparing the other science process skills, namely, "collection of data", "analysis of data", "use of nominal scientific knowledge to communicate results", "use of models to explain results", and "use of results to answer the question" have *p*-values which are higher than the alpha level set at 0.05 using the Mann-Whitney U test ($p_{value} < \alpha_{0.05}$). This entails that the study failed to reject the null hypothesis which states that there is no significant difference in the SPS level between the experimental group and control group along these domains. This means that the personality-based approach (PBA) did not increase the SPS level of the students. Hence, the need to either improve the implementation of the said approach to better these science process skills.

While intelligence is proven to predict the academic performance of students. However, a multitude of studies shows the need to look at other non-cognitive factors that are responsible for this performance. This study successfully surfaced the importance of considering personality as a facet towards holistically addressing the individual needs of students.

Conclusions and Recommendations

Summary of Findings

Based on the findings, the following are therefore concluded: Individually, the experimental group who was given the personality-based approach (PBA) performed high with their science process skills while the control group which was given with the conventional approach have typical science process skill level.

When compared, the experimental group have better performance in the skills where students are to prepare research proposals than their counterpart in the control group. However, in terms of the experimentation process down to creating models, the two groups do not differ.

Recommendations

The researcher recommends the use of a personality-based approach (PBA) in classroom instruction in teaching the integrated science process skills to the STE students. Improvements on its implementation are recommended to be considered to address other domains of the science process skills especially in the experimentation part down to coming up with a model to answer the objectives of the research being advanced. Since this learning approach is found efficient in catering for the unique needs of learners, personality styles can be emphasized more in the curriculum. Lastly, a meta-analysis study can be conducted to investigate why some of the domains were not significantly increased by the proposed personality-based approach (PBA).

As an offshoot of the general findings of the present study, a learner's material called Personality Style-based Learner's Module (PSBLM) to differentiate research activities for the two personalities – introversion and extroversion was formulated, and in turn, improving the proficiency of Grade 7 students in Research 1. Previous research tells a correlation between the academic performance of the learners in Science and their type of personality, this suggests a differentiated approach in their way of understanding concepts. Introversion, being the quiet ones, prefer a type of autonomous learning while extroversion prefers interactive activities.

This module covers Science topics from the first quarter to fourth quarter for Grade 7 Research specifically on the students integrated science process skills. The module consists of differentiated formative activities aimed to provide the two types of learners (introversion and extroversion) specialized activities that will aid their understanding of the various Science and Research concepts. It should be remembered, however, that introversion-extroversion is a continuum and not a dichotomy. The aim of the module is not to totally divide the class according to their type of personality. One cannot simply dichotomize the class in half and put the introverts into a quiet setting and the extroverts into a more stimulating setting. Introduction to the concepts and summative assessments will still be unanimous for these two since the goal of the current study is to improve students' science process skills, and in effect improve their performance in a scientific investigation.

Acknowledgements

This work would not have been possible without the financial support of the Policy, Planning, and Research Division (PPRD) through the Basic Education Research Fund (BERF) of the Department of Education. I am especially indebted to the Planning and Research Office of the Division of Baguio City, particularly Dr Reynalyn T. Padsoyan, for the unconditional support in completing this research work.

I am personally grateful to Dr Mary Arnold (College of Public Health and Human Sciences, Oregon State University) who allowed me to use the Science Process Skills Inventory which she and Dr Bourdeau developed.

I am also indebted to all those with whom I have had the pleasure to work during this project especially to the Science, Technology, and Engineering (STE) students who willingly participated in my study and from whom I got the very data I needed to orchestrate its objectives. Special mention also to the administration of Baguio City National Science High School for allowing me to conduct this research.

References

Al-Naggar, R., Osma, M., Ismail, Z., Bobryshev, Y., Ali, M., & Gonzales, M. (2015). Relationship between type of personality and academic performance among Malaysian health sciences students. *International Archives of Medicine, 8(182). https://doi.org/doi:10.3823/1781*

Aktamis, H. & Ergin, O. (2008). The effect of scientific process skills education on students' scientific creativity, science attitudes and academic achievements. *Asia-Pacific Forum on Science Learning and Teaching, 9 (1)*. Retrieved from https://www.ied.edu.hk/apfslt/v9_issue1/aktamis/aktamis2.htm

Arnold, M., & Bourdeau, V. (2009). Science process skills inventory (SPSI). Corvallis, OR: 4-H Youth Development Education, Oregon State University.

Barakat, A. & Othaman, A. (2015). The five-factor model of personality and its relationship to cognitive style (rush and prudence) and academic achievement among a sample of students. *Journal of Education and Practice, 6 (25).*

Ciorbea, I. & Pasarica, F. (2013). The study of the relationship between personality and academic performance. *Procedia – Social and Behavioral Science, 78, 400-404. https://doi.org/10.1016/j.sbspro.2013.04.319*

Dacumos, L. N. (2016). Perspective of teachers in the utilization of science strategic intervention material in improving proficiency in science education. *Association of Southeast Asian Teacher Education Network (AsTEN) Journal of Teacher Education. 2 (1). ISSN: 2467-7825; 2507-8100*

Dacumos, L. N. (2016). Personality styles, stress-coping mechanisms and academic performance of students in the 10 newly legislated schools in Baguio City. *Journal of Accountancy, Management, Education and Research (JAMERP). Manuscript accepted for review and publication*

Dacumos, L. N. (2016). Influence of personality styles and stress-coping mechanisms on the academic achievement of students in science 9 in HHNHS. *Patawid di Adal,* 1(1), 73.

De Raad, B. & Schuwenburg, H. (1996). Personality in learning and education: A review. *European Journal of Personality, 10(5). https://doi.org/10.1002/(SICI)1099-0984(199612)10:5%3C303::AID-PER262%3E3.0.CO;2-2*

Eison, J. (2010). Using active learning instructional strategies to create excitement and enhance learning. Retrieved from https://www.cte.cornell.edu/documents/presentations/Eisen-Handout.pdf

Gultepe, N. (2015). High school science teachers' views on science process skills.

International Journal of Environmental & Science Education. 11(5), 779-800.

Hanson, T. (n.d.). Stat 705: Completely randomized and complete block designs. Retrieved from http://people.stat.sc.edu/hansont/stat705/Design1.pdf

Jang, J., Hwang, W., & Cho, S. (2016). Relationship between Personality Type and Academic Achievement of Korean Medical Students. *Journal of Physiology and Pathology in Korean Medicine.* 30 (1), 61. http://dx.doi.org/10.15188/kjopp.2016.02.30.1.61

Karamustafaoglu, S. (2011). Improving the science process skills ability of science student teachers using I diagrams. Eurasina J. Phys. Chem.Edu. 3 (1), 26-38. https://doi.org/10.51724/ijpce.v3i1.99.

Kennedy, R., & Herring, S. (2016). Knowledge of personality types can enhance instructional programs. College of Business, Athens State University. Retrieved from http://www.athens.edu/journal/spring-2016/knowledge-of-personality-types-can-enhance-instructional-programs/

Mojer, M. (2015). Effective communication, better science. Retrieved from https://blogs.scientificamerican.com/guest-blog/effective-communication-better-science/

Molefe, L., Stears, M., & Hobden, S. (2016). Exploring student teachers' views of science process skills in their initial teacher education programmes. *South African Journal of Education, 36 (3). http://dx.doi.org/10.15700/saje.v36n3a1279*

Oates, J., Kwiatkowski, R., & Coulthard, L.M. (2009). Code of Human Research Ethics. Retrieved from http://www.bps.org.uk/sites/default/files/documents/code_of_human_research_ethics.pdf

Ogbu, J. (2015). Influences of inadequate instructional materials and facilities in teaching and learning of electrical/electronictechnology education courses. *Journal of Education and Practice. 6 (33), 39-46.* Retrieved from http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=EJ1083540

Perrine, J. (2017). The benefits of understanding personality types in the workplace. Retrieved from https://allthingsadmin.com/administrative-professionals/benefits-understanding-personality-types-workplace/

Rabacal, J. (2016). Test of science process skills of Biology students towards developing of learning exercises. *Asia Pacific Journal of Multidisciplinary Research. 4 (4)*

Rezba, R. (1999). Teaching and learning the basic science skills: Videotape series. Office of elementary and middle school instructional services, Virginia Department of Education.

Sadeghi, N., Kasim, Z., Tan, B., & Abdullah, F. (2012). Learning styles, personality types and reading comprehension performance. *English Language Teaching, 5 (4).*

Salem al-amarat, M. (2011). The classroom problems faced teachers at the public schools in Tafila Province, and proposed solutions. Retrieved from http://krepublishers.com/02-Journals/IJES/IJES-03-0-000-11-Web/IJES-03-1-000-11-Abst-PDF/IJES-3-1-037-11-041-Al-Amarat-M-S/IJES-3-1-037-11-041-Al-Amarat-M-S-Tt.pdf

Science Learning Hub. (2011). Scientific modelling. Retrieved from https://www.sciencelearn.org.nz/resources/575-scientific-modelling

Shalabh, I. (n.d.). Experimental design and their analysis. Retrieved from http://home.iitk.ac.in/~shalab/anova/chapter4-anova-experimental-design-analysis.pdf

Streubert-Speziale, H.J. & Carpenter, D.R. (2003). Phenomenology as method. Philadelphhia, PA: Lippincott Williams & Wilkins.

Supriyatman & Sukarno (2014). Improving science process skills (SPS) science concepts mastery (SCM) prospective student teachers through inquiry learning instruction model by using interactive computer simulation. *International Journal of Science and Research (IJSR), 06-09*

Tucker, C. (2011). Differentiated instruction: What is it? Why is it important? How can technology help? Retrieved from http://catlintucker.com/2011/01/differentiated-instruction-what-is-it-why-is-it-important-how-can-technology-help/

Turiman, P., Omar, J., Daud, A., & Osman, K. (2011). Fostering the 21st century skills through scientific literacy and science process skills. *Procedia – Social and Behavioral Sciences, 59, 110-116*

Weselby, C. (2016). What is differentiated instruction? Examples of how to differentiate instruction in the classroom. Retrieved from http://education.cu-portland.edu/blog/teaching-strategies/examples-of-differentiated-instruction/

Wiles, R., Crow, G., Heath, S., & Charles, V. (2006) Research Methods. Anonymity and Confidentiality. Retrieved from http://eprints.ncrm.ac.uk/423/1/0206_anonymity%2520and%2520confidentiality.pdf

Zeidan, A. & Jayosi, M. (2014). Science process skills and attitudes toward Science among Palestinian secondary school students. *World Journal of Education,* 5 (1).

Zouaoui, M. (n.d.). The importance of research proposal. Retrieved from https://www.univ-sba.dz/med_dialogue/images/Article.8/23.pdf

2021

SEAQIS Journal of Science Education (SciEd)
P-ISSN: 2777-0397 | E-ISSN: 2798-7175
Vol: 1, No: 2, PP:49-59
www.journal.qitepinscience.org

Research Paper

Open Access

Metacognitive Strategy of Chemistry Teacher Candidates in Chemistry Reading Activity

Benny Yodi Sawuwu [1]

[1] *SMA Katolik Santu Petrus Pontianak, West Kalimantan, Indonesia.*

Abstract

This qualitative study was conducted to explore the metacognitive strategy of chemistry teacher candidates in reading activities of a chemical article. There were 15 female chemistry teacher candidates voluntarily on this research from a public university. A chemical article that fulfilled some characteristics was used to stimulate the metacognitive activity, and 25 open-ended questions were posed for self-interviewing to reveal the metacognitive aspects. A think-aloud protocol was conducted during the reading activity. All reading activities were recorded and transcribed. Transcription of the think-aloud activity was considered to the reading rate to classify the think-aloud style into less think-aloud, formal think-aloud, and critical think-aloud. The reading pattern and data from self-interview showed that these three styles of think-aloud had different strategies on chemistry reading activity. The planning and evaluating activity determined the strategy chosen on reading. The monitoring activity was contributed by terms and chemical representatives used in the article.

Keywords: Chemistry reading activity, Metacognitive strategy, think-aloud

Introduction

When one reads an academic reading, like chemical information, will occur cognitive and metacognitive strategies concurrently in his/herself (Korpershoek, Kuyper, & van Der Werf, 2015; Leopold & Leutner, 2015). The question posed as the result of reading the chemical information could become an indicator to reveal one's metacognitive levels related to his/her understanding of the chemistry and context of the reading (Kaberman & Dori, 2009; Herscovitz, Kaberman, Saar, & Dori, 2012; Ghasempour, Bakar, & Jahanshahlolo, 2013). However, this metacognitive aspect is difficult to observe since the process occurs inside one's mind (Dunlosky & Metcalfe, 2009; Norris & Phillips, 2012; Grotzer & Mittlefehldt, 2012; Schraw, Olafson, Weibel, & Sewing, 2012). Divulging metacognition through problem posing in question-form could be handled by combining the question taxonomy with the think-aloud protocol (Kaberman & Dori, 2009; Herscovitz, et al., 2012) that is a technique to verbalize one's thought (Jacobse & Harskamp, 2012). The advantage of this technique is to give the sight of the process of memory and actual thinking when one is reading, understanding, strategizing, processing, and deciding (Wilhelm, 2001; Overton, Potter, & Leng, 2013) for revealing the metacognitive strategy (Binbarasan-Tüysüzoglu & Greene, 2015), metacognitive judgment (Ben-Eliyahu & Bernacki, 2015), and metacognitive knowledge in problem-posing (Herscovitz, et al., 2012).

The qualitative analysis could get a whole description of those metacognitive phenomena (Davidowitz & Rollnick, 2003; Pulmones, 2010; Siegel, 2012; Anderson, Nashon, & Thomas, 2009; Thomas &

McRobbie, 2013). One of the qualitative approaches that could be used is the phenomenological study (Vierkant, 2017). Nevertheless, this qualitative approach had a shortcoming because of its long time needed (Jacobse & Harskamp, 2012). Pulmones (2010) covered it by analysing in-depth the representative samples as found similar epistemological beliefs of students with the same metacognitive type.

Chemistry teacher candidates, as the agents to assess the students' metacognitive, should have the capacity to read the chemical reading and to pose the chemical problem before they would assess their students in the future. Particularly in the chemistry domain that has certain characteristics that evolve during the world development in this 21st century. This research was conducted to explore the metacognitive strategy of chemistry teacher candidates in the reading activity of a chemical article. This study would reveal the reading pattern and the reading strategy in chemistry teacher candidates.

Methods: Participant

This was a qualitative study of 15 chemistry teacher candidates in third years of a public state university in Yogyakarta, Indonesia. All of them were female and from 19 to 21 years old. They were in the international program that used a bilingual class in Indonesian Language and English during their courses. They participated voluntarily in this research outside the regular class activities. Ethical consideration was used to protect the data of participants (Taber, 2014; Sadowski & McIntosh, 2015) that was stamped in an agreement between each participant and the researchers. They were denoted by participants A to O.

Material

A chemical reading had been designed to stimulate metacognitive strategy in the reading activity.

The reading was an article about the application of chemical equilibrium in human teeth overlapping with other chemistry domains and other disciplines, that fulfilled some criteria about chemical reading as mentioned before, to stimulate the participants as readers to pose problems in question form at the metacognitive level. The title of the article is "Teeth Demineralization and Remineralization". It is an interdisciplinary topic with a total of 1095 words and uses multi representations. The article had been validated by two experts in related disciplines, and some suggestions from the experts had been used to consummate the reading. The phenomenology figures were placed in paragraphs 1 and 5, the model figure placed in paragraph 8, and the symbolic figure was placed in paragraph 5. Four chemical equations were placed in paragraphs 1, 2, and 8.

There were 25 questions of metacognitive strategy exploratory arranged to reveal another metacognitive activity that was not observed during the reading and posing question activities. The questions were made based on the indicators in Table. 1. The questions were open-ended and had been validated by two experts on chemistry education and psychological education. Some suggestions from experts had been used to complete the questions' visibility.

Table 1. Component of Dimension Metacognitive Strategy

Dimension	Aspect	Indicators
Planning	Recognition	recognize the category of task instruction
		read the information given
		think about what one own self knows about the task information
		think about what one own self does not know about the task information
	Identification	identify the relevant data
		identify the goal of the task

Dimension	Aspect	Indicators
	Comprehension	identify the relevant data that is not found from the information
		make your sketch about the information
		list the alternative methods that can be used to rich the goal
	Organization	list the sequence of procedure
		allocate the time in each sequence step
Monitoring	Firming up	re-read the information till getting the whole understanding
		try to understand the difficult, new, or unfamiliar data
	Thinking process	use a specific method to organize the data (e.g. graph, note, table, etc.)
		review the reference (the knowledge outside the information)
		solve the problem that appears subsequently
	Exactitude	review the solution
		re-analyse the examination conducted
	Congruence	check the progress
		ask for others' perspectives (friends or examples)
Evaluating	Examination	check the attainment
		check the success of the strategy used
	Reflection	assess the strategy based on the self-performance about the quality of the task given
	Appreciation	assess how to study the learning strategy in a different context
		appreciate own self after finishing the task

Procedure

The task was decided to be the purpose of the reading activity. Each participant should pose two problems in question-form after they read the article as the result of thinking and reflection of the article. The specific directions of the questions were (1) they should be the best complex problems consisting of the initial information and the final state, (2) they should be fetched us on the application of chemical equilibrium on the article's context, and (3) they could link another knowledge to pose the question but they should anchor to the chemical equilibrium and its application. After they made the questions, they should answer the open-ended questionnaire by themselves. The time was limited to 45 minutes to finish their activities.

A think-aloud protocol was used in this reading procedure to collect about metacognitive activities during reading the article. First, each participant was given the reading and had been simulated about the procedure of think-aloud for recording. Each participant had been requested to vocalize or verbalize their thoughts in front of the recorder during they were reading. There was no pause activity during reading, posing the question till answering the questionnaire. The participants were allowed to drink during the think-aloud activity if they felt husky. 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 the researcher's interruption, at the comfort place that participant selected before, and in their spare time.

Credibility

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

Analysing Data

The data collected from the recording were transcribed and validated by the participants. How they read the articles was transcribed and marked in specific coding consisting of reading patterns and reading parameters. The transcription was arranged embedding and sequentially between the textual word and think-aloud word. Every segment (sentences, equations, and figures/graphs) was measured to the reading rate. This measurement was just only for categorizing the data in the detailed segment of reading patterns. Next, seeking for the difference or delta (Δ) between the reading rate of think-aloud and textual word (relative to the time spent of each participant) was conducted to analyse the reading pattern and to find "what" the metacognitive activities during the reading process. The delta described the reading pattern. The positive value of delta showed that participants were more in think-aloud. The zero value of delta showed that participants were equal on think-aloud and normally textual words. The negative value of delta indicated that participants were less on think-aloud, did not read the words, and stayed silent several times.

The margin of error of the delta was determined as the multiplication product of standard error with critical value. Standard error was defined as the standard deviation of the delta divided by the square root of the participant number. The critical value was a z-score for one minus half of the significant level ($\alpha = 5\ \%$). For participants who had the delta above the positive margin of error were classified as critical-think-aloud. For participants who had the delta between the positive and negative margin of error were classified as formal-think-aloud. For participants who had the delta below the negative margin of error were classified as less-think-aloud.

A phenomenological reduction method was used to analyse the reading phenomena. All data were transcribed then were reduced (horizontalization of data).It was carried by deleting the statements of think-aloud expressions that were not relating 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 coded and categorized in the same theme that represented the specific expression and finding toward the metacognitive strategy in the reading activity of the chemical article. The coding from the reading pattern was used to find pneumatic themes (what the phenomenon is) and the coding from the think-aloud activity and self-interview was used to find noesis themes (how the phenomenon is).

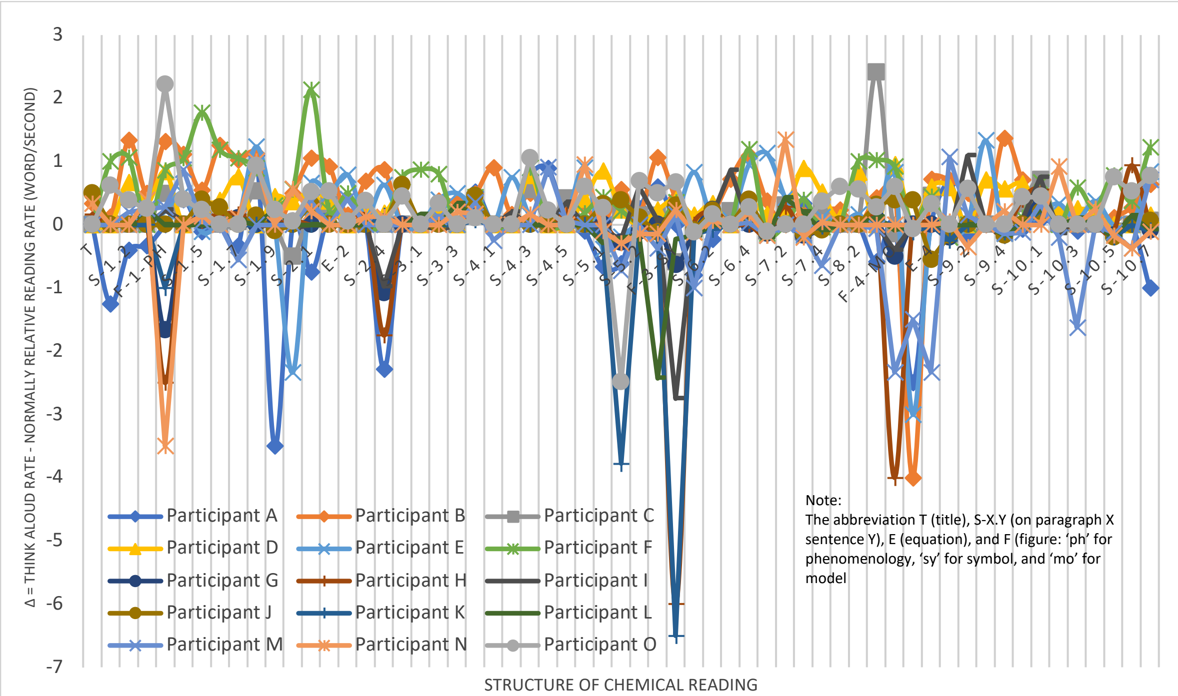
Then, data verification was conducted to clarify and reinforce the themes. The pneumatic themes were unified as formulation of the textural definition but the neosis themes were as the structural definition. By blending the textural and structural definitions and adding with data interpretation, the themes were merged to be the essential definition of metacognitive strategy in chemistry reading activity.

Result and Discussion

Chemistry Reading Pattern

The distribution of reading rate based on the structure of chemical reading was shown in Fig. 1. According to this delta (margin of error = 0,1258), we can classify the reading pattern on three types of chemical reading activities. Participants B, C, D, E, F, J, N and O were grouped on critical-think-aloud. Participants G, H, I, L and M were categorized on formal-think-aloud. The less-think-aloud group was occupied by participants A and K. These three chemical reading activities had a similar trend on reading the figure of chemical representatives (phenomenology, model, and symbolic) and the chemical equations. They would decelerate their reading rate when arrived at the figures and equations as the specific characteristic of chemical readings.

Figure 1. The pattern of Chemical Reading



The main differences between these three styles were the reflection about the content of the article during they read (the critical-think-aloud was the most reflective reading style) and the strategy of reading they used. The critical-think-aloud reading style was not always produced by one that had a metacognitive strategy, because some reflections made was only just expressions about agreement and familiarity. On contrary, few reflective or metacognitive expressions were elicited in a less-think-aloud style. There were some activities on critical think-aloud appearing on formal-think-aloud and less-think-aloud.

Planning activity on chemistry reading activity

Recognition of the task as the purpose to read was conducted by all think-aloud styles. It was an important thing to begin the chemistry reading activity. For critical-think-aloud style, the recognition about the task focused on the process that should be conducted about the task instruction, how the limitation is given like time allocation, how the requirement can or cannot be conducted, what the sources should be used (chemical equilibrium theory and application), and what the goal that should be reached after reading (to pose questions). For formal-think-aloud and less-think-aloud only focused on the process, limitation and the goal. The differences between them were on identification and comprehension of the task. The less-think-aloud decided to read rapidly and sequentially as the best strategy to manage the time given and to simplify effectively the think-aloud technique. Nevertheless, the formal-think-aloud tended to not consider the time given when reading, but just flowing naturally (relative in the range positive and negative of margin of error). The time was considered to be more left after reading to posing questions. This style arranged the strategy to have understanding during reading activity sequentially but in simple ways by reducing the think-aloud activity.

The critical-think-aloud considered the process, limitation, and the goal toward the requirements and the sources needed and used them to arrange the criteria to reach the goal. After they knew the topic of the passage, they expected some chemical aspects that may be found during reading.

They predicted some important things that should be searched by linking the preliminary knowledge related to being marked during reading. On less-think-aloud would read directly after this prediction making, but on formal-think-aloud, they initiated the reading activity by looking a moment the interesting part of the passage like figure, bold sentences, etc., before reading the title and memorizing the terms and related terms on the title.

After making the prediction, the critical-think-aloud style would count the pages to estimate the time by skimming. Scanning would be conducted to find the chemical aspect of the reading or to see a moment of the interesting part of the passage like figure, bold sentences, etc., before reading the title. Then read the terms and related terms on the title. In that, the critical-think-aloud had the more detailed on planning to read the chemical reading. The critical-think-aloud tended to be critical-based on reading planning not only process-oriented (through understanding the think-aloud protocol and estimating the strategy) but also result-oriented (through arranged the criteria of question should be made and predicted what the things should be found).

Monitoring activity on chemistry reading activity

When the reading process was ongoing, one was seeking for the familiarity or similarity about each word read. These were conducted by comparing the data and preliminary knowledge such as some terms. When the familiar data were found, the less-think-aloud would reduce them from his/her voice, but the formal-think-aloud would read them rapidly. The critical-think-aloud would find the new information from the familiar data for renewing the understanding and would criticize the gap between them. When the new, strange, and interesting terms were found, all think-aloud types would be slower on reading and would try to understand them. The monitoring in this chemical reading activity was carried on the understanding section of the chemical information, figures or graphs, and terms. This monitoring step would determine how to go forward or to have some iteration. During the efforts to seek familiarity and to find the understanding, they should mark the important information following the task instruction and the planning made before.

The critical-think-aloud would predict or make its definition (about the terms) and explanation (about the statement) through identifying the hint about them, before and/or after statements, as shown by this quotation of text S-1.8 below.

Text S-1.8	:	This process is called teeth mineralization
Less think-aloud (K)	:	This process is called teeth mineralization [3 seconds)
Formal think-aloud (G)	:	This process is called teeth mineralization [silent] (6 seconds)
Critical think-aloud (B)	:	This process is, this process is called teeth mineral, teeth mineralization. Matrix protein combines with water ... it means that contain mineral so why it is called teeth mineralization. (32 seconds)

The quotation above showed that the formal-think-aloud had tried to understand the sentence by decelerating the speed but she was trapped in puzzled and difficult to think-aloud. On another side, the less-think-aloud had judged that the term was not important because she thought that not all terms should be used to make a question.

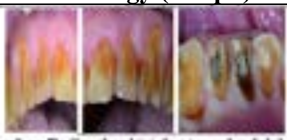
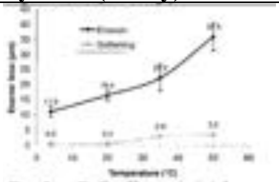
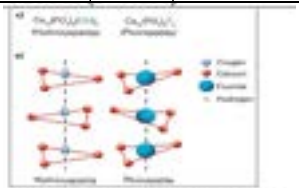
When they found the chemical equation the less-think-aloud tend to pass it, as shown by this quotation of text E-2 below.

Text E-2	:	$Ca_{10}(PO_4)_6(OH)_2(s)$ + $8H^+(aq)$ → $10Ca^{2+}(aq)$ + $6HPO_4^{2-}(aq)$ + $2H_2O(l)$
Less think-aloud (A)	:	-
Formal think-aloud (L)	:	$Ca_{10}(PO_4)_6(OH)_2$(solid) added by $8H^+$(aqueous) becomes $10Ca^{2+}$(aqueous) plus $6HPO_4^{2-}$ (aqueous) plus $2H_2O$(liquid) [11 second]
Critical think-aloud (F)	:	This is the demineralization reaction, $Ca_{10}(PO_4)_6(OH)_2$ added by $8H^+$, reacted with an acid, produce, oh, $10Ca^{2+}$ plus $6HPO_4^{2-}$ plus $2H_2O$, ha [what] HPO_4^{2-}? Oh it is acid, it means, with acids such as from bacteria, ehe [agree]. [36 seconds]

The formal-think-aloud just read the equation as a formal activity but the critical-think-aloud would identify the component on the chemical equation, find the connection of the sentences on the text and the equation, and criticize the new, strange, unfamiliar, and unreasonable partitions.

Figure 1 before showed that were negative delta values in each figure of chemical representative. For analysing the detail of each figure, Table 2 had showed the comparison.

Table 2. Think-aloud Activity for Chemical Representatives

	Phenomenology (F-2.ph)	Symbol (F-3.sy)	Model (F-4.mo)
Text (in Bahasa Indonesia)	 **Gambar B**: Gambar kiri dan tengah adalah erosi gigi akibat makanan asam dan trauma menyikat gigi pada seseorang berusia 70 tahun dengan pulp gigi yang sehat. Gambar kanan adalah erosi gigi yang terjadi pada penderita anoreksia dan bulimia berusia 35 tahun (Sumber: Colon & Lussi, 2014)	 **Gambar C**: Grafik erosi gigi dan pelunakan gigi selama 2 jam dalam asam sitrat (pH=3,2) dalam berbagai suhu cairan yang berbeda (Sumber: Eisenburger & Addy, 2003)	 **Gambar D**: Ion fluorida menggantikan posisi ion hidroksida dari hidroksiapatit menjadi fluorapatit (Sumber: (http://www.dentalcare.com)
Less think-aloud (A)	[read the text of figure explanation] there is something black, what is it? [21 seconds]	(0 seconds)	(0 seconds)
Formal think-aloud (I)	[read the text of figure explanation] [22 seconds]	[read the words on figure] [8 seconds]	[read text of figure explanation] (silent) [10 seconds]
Critical think-aloud (C)	How odious it is, yellow. [read the text of figure explanation] why could it be black? Anorexia, bulimia are diseases that spew the food out after eating, so scrawny. [50 seconds]	Eh [shock], oh the higher the temperature, the more it is? The more tooth enamels diminished [20 seconds]	Is it its geometry? Its geometry molecule? Apatite, Apatit…, forget it. [13 seconds]

According to Table 2, there was a trend of depletion of chemical comprehension from phenomenology to model representative for all think-aloud types. The think-aloud could be an indicator for revealing the understanding of the text. As mentioned by them that, "*I am understand, when I can re-tell what I read*", or "*if I do not understand, I will re-read again.*"

The less-think-aloud just saw the figure at a glance without determination because of the reason of sparing time. They thought that was becoming more advantageous when initiating mini questions to be options for the final question. The mini questions were the gap between the curiosity of the text written and preliminary knowledge. This mini question usually was on the new terms or important information marked by them.

Some cases were the gap between their experiences and the statements or new knowledge they found in the text.

For the less-think-aloud, iteration should be minimum (maximum two iterations) as a strategy. For the formal and critical think-aloud, iteration should be an alternative for more understanding about the text through considering the length of the passage left. By re-considering, the length of passage left and the time prediction, they would monitor and re-plan what they had to do to reach the goal of the task. The first depletion of motivation appeared on S-2.3 (230 words) and the peak of this depletion was on S-6.4 (690 words). It meant that the capacity of students to get more concentration in reading just 200-700 words. The range from S-2.3 to S-6.4 was the spots for mini-questions arranged and the spots for reflective expression appeared. After this range, the graph was flat to the minimum expression.

Looking for this monitoring activity on chemistry reading activity, seemed that by think-aloud activity during this reading activity all participants were carrying some metal actions. They elaborated the time for retention and performance (Eitel & Kuhl, 2016). During they were reading, they were detecting some errors toward their preliminary knowledge (Garcio-Rodicio & Sanchez, 2014) and were sorting the chemical alarms like symbols on terms, chemical formula and others figure (Green & Redford, 2015).

Evaluating activity on chemistry reading activity

As a strategic reason, the less-think-aloud said that they did not check their understanding of the text during the reading activity. On other hand, the formal and critical think-aloud tried to terminate the reading activity by making some reflection about the text through the link the data to personal experiences or preliminary knowledge on daily life. By retelling the information, they evaluate what they understand about the text and how they comprehend the whole text. After reading they checked again the goal that should be reached on the task. This was as reinforcement to the understanding and making sure they had known about the task.

Planning, monitoring, and evaluating activities could not be separated independently. After one planned and monitored the process, evaluation needed to re-design the planning. The reading rate would be fluctuating when the reflective reading had been conducted. Chemical reading, with all components of chemical characteristics, should be read by different strategies compared with other readings. As an unseparated part of chemical literacy, the attainments in these reading activities were affected by the lower multi-dimensional chemical literacy that impacted the insufficient reasoning and comprehension about the reading activity (Celik, 2014). So, the teacher candidate should improve themselves on chemical literacy.

Conclusion and Implication

Think-aloud in reading activity had trained the teacher candidate how to understand the task to get the more efficient strategy in metacognitive level. When they should voice the thought about the passage they read, they thought twice and moved to the metacognitive mode. Less-think-aloud, formal-think-aloud, or critical-think-aloud should be arranged by an effective strategy for planning, monitoring, and evaluating activities. As the teacher candidate, an obligation was to understand this reading strategy in chemical reading activities. The conformation of chemical representative in a chemical reading effect the chemical understanding of the readers.

Through the specific task given at the beginning of the reading activity, like posing questions, trained ones to know the goals of reading. It was not about selecting a type of reading way but it was about determining how to be effective on reading. The chemical reading, with its components, had characterized the multiple representatives for stimulating the metacognitive expression. It was important to help readers visualize what the chemical and its properties were spoken. By giving a limitation of the task, could stimulate readers to arrange the strategy when collecting the information during the reading activity. Think-aloud made the strategy be stimulated on the metacognitive reflective level and revealed the strategy used in the readers' minds.

Monitoring activities during reading determined the iteration, prediction, interpretation, and comprehension of the text. The new, unfamiliar chemical terms inserted on the text could be sensors or hints by the mind for marking the specific information for considering to list the important data. This monitoring was closer to the identification of familiarity and understanding of the chemical representative on the text. This identification caused the speed to be slower or faster. The more new related and important terms, the slower the speed. Chemical representative in phenomenology-contextual could be the important part to visualize the text but could be not too contributed if the readers judged it was not important for the task goal. The symbolic and model could be important to stimulate the readers to think on the level of chemical understanding. But the length of the passage should be determined to prevent the contribution of motivation depletion during reading. Interesting confirmation reading arrangement and limitation of words used could be the alternative solution to maintain the motivation and concentration of the reader during the chemistry reading activities.

Retelling and making a reflection about the text would convey the readers to evaluate the understanding about the chemical reading. The interlude section was more important to guide readers for reading comprehension. As teacher candidates, the critical-think-aloud style on chemical reading should be trained to firm the chemical understanding up about the written data. It helped chemistry teacher candidates to be the criticized and open-minded teachers.

Acknowledgement

Thank you to Indonesia Endowment Fund for Education (LPDP) for funding this research.

Reference

Anderson, D., Nashon, S. M., & Thomas, G. P. (2009). Evolution of research methods for probing and understanding metacognition. *Research in Science Education, 39*, 181-195. doi:10.1007/s11165-007-9078-1

Ben-Eliyahu, A., & Bernacki, M. L. (2015). Addressing complexities in self-regulated learning: a focus on contextual factors, contingencies, and dynamic relations. *Metacognition Learning*, *10*, 1-13. doi:10.1007/s11409-015-9134-6

Binbarasan-Tüysüzoglu, B., & Greene, J. (2015). An investigation of the role of contingent metacognitive behaviour in self-regulated learning. *Metacognition Learning, 10*, 77-98. doi:10.1007/s11409-014-9126-y

Celik, S. (2014). Chemical literacy levels of science and mathematics teacher candidates. *Australian Journal of Teacher Education, 39*(1), 1-15. doi:10.14221/ajte.2014v39n1.5

Davidowitz, B., & Rollnick, M. (2003). Enabling metacognition in the laboratory: A case study of four second-year university chemistry students. *Research in Science Education, 33*, 43-69. doi:10.1023/A:1023673122220

Dunlosky, J., & Metcalfe, J. (2009). *Metacognition*. Los Angeles, LA: Sage.

Eitel, A., & Kuhl, T. (2016). Effects of disfluency and test expectancy of learning with text. *Metacognition Learning*, *11*(1), 107-121. doi:10.1007/s11409-015-9145-3

Garcia-Rodicio, H., & Sanchez, E. (2014). Does the detection of misunderstanding lead to its revision? *Metacognition Learning*, *9*(3), 265-286. doi:10.1007/s11409-014-9116-0

Ghasempour, Z., Bakar M. N., & Jahanshahloo, G. B. (2013). Innovation in teaching and learning through problem-posing tasks and metacognitive strategies. *International Journal of Pedagogical Innovations*, *1*(1), 53-62. Retrieved from https://journal.journals.uob.edu.bh//Article/ArticleFile/158

Green, S. R., & Redford, J. (2016). Metasearch accuracy for letters and symbols: Do our intuitions match empirical reality? *Metacognition Learning, 11*(2), 237-256. doi:10.1007/s11409-015-9143-5

Grotzer, T. & Mittlefehldt, S. (2012). The role of metacognition in students' understanding and transfer of explanatory structures in science. In A. Zohar & YJ. Dori. (Eds). *Metacognitive in Science Education: Trends in Current Research Series: Vol. 40 Contemporary Trends and Issues in Science Education* (pp. 79-99). Dordrecht: Springer.

Herscovitz, O., Kaberman, Z., Saar, L., & Dori, Y. J. (2012). The relationship between metacognition and the ability to pose questions in chemical education. In A. Zohar & Y. J. Dori. (Eds.). *Metacognitive in Science Education: Trends in Current Research, Series: Vol. 40. Contemporary Trends and Issues in Science Education* (pp. 165-195). Dordrecht: Springer.

Jacobse, A. E., & Harskamp, E. G. (2012). Towards efficient measurement of metacognition in mathematical problem-solving. *Metacognition Learning,* *7*(2):133-149. doi:10.1007/s11409-012-9088-x

Kaberman, Z & Dori, Y. J. (2009). Metacognition in chemical education: Question posing in the case-based computerized learning environment. *Instructional Science, 37*(5): 403-436. doi:10.1007/s11251-008-9054-9

Korpershoek, H., Kuyper, H., & van Der Werf, G. (2015). The relation between students' math and reading ability and their mathematics, physics, and chemistry examination grades in secondary education. *International Journal of Science and Mathematics Education*, *13*(5), 1013-1037. doi:10.1007/s10763-014-9534-0

Leopold, C., & Leutner, D. (2015). Improving students' science text comprehension through metacognitive self-regulation when applying learning strategies. *Metacognition Learning, 10*(3)*,* 313-346. doi:10.1007/s11409-014-9130-2

Norris, S. P., & Phillips, L. M. (2012). Reading Science: How a naive view of reading hiders so much else. In A. Zohar & Y. J. Dori. (Eds.). *Metacognitive in Science Education: Trends in Current Research Series: Vol. 40 Contemporary Trends and Issues in Science Education* (pp. 37-56). Dordrecht: Springer.

Overton, T., Potter, N., & Leng, C. (2013). A study of approaches to solving open-ended problems in chemistry. *Chemistry Education Research and Practice, 14*, 468-475. doi:10.1039/c3rp00028a

Pulmones, R. (2010). Linking students' epistemological beliefs with their metacognition in a chemistry classroom. *Asia-Pacific Education Researcher*, *19*(1), 143-159. Retrieved from http://ejournals.ph/form/cite.php?id=3981

Sadowski, C., & McIntosh, J. E. (2015). A phenomenological analysis of the experience of security and contentment for latency aged children in shared-time parenting arrangements. *Journal of Phenomenological Psychology*, *46 (1)*, 69-104. doi:10.1163/15691624-12341285

Schraw, G., Olafson, L., Weibel, M., & Sewing, D. (2012). Metacognitive knowledge and field-based science learning in an outdoor environmental education program. In A. Zohar & Y. J. Dori. (Eds.). *Metacognitive in Science Education: Trends in Current Research Series: Vol. 40 Contemporary Trends and Issues in Science Education* (pp. 57-77). Dordrecht: Springer.

Siegel, M. A. (2012). Filling in the distance between us: Group metacognition during problem solving in a secondary education course. *Journal of Science Education Technology, 21*, 325-341. doi:10.1007/s10956-011-9326-z

Taber, K. S. (2014). Ethical considerations of chemistry education research involving 'human subjects'. *Chemistry Education Research and Practice*, *14*, 109-113. doi:10.1039/c4rp90003k

Thomas, G. P., & McRobbie, C. J. (2013). Eliciting metacognitive experiences and reflection in a year 11 chemistry classroom: An activity theory perspective. *Journal of Science Education Technology, 22*, 300-313. doi:10.1007/s10956-012-9394-8.

Vierkant, T. (2017). Choice in a two-system world: Picking & weighing or managing & metacognition. *Phenomenology and The Cognitive Science (*pp. 1-13). Dordrecht: Springer.

Wilhelm, J. D. (2001). *Improving comprehension with think-aloud strategies.* New York, NY: Scholastic Professional Books. Retrieved from http://gec.kmu.edu.tw/~lc/ecorner/eBook/Improving%20Comprehension%20With%20Think-Aloud%20Strategies.pdf

SciEd
SEAQIS Journal of Science Education
Jl Diponegoro no 12 Bandung, West Java 40115, Indonesia
+62 22 421 8739 secretariat@qitepinscience.org
+62 22 421 8749 www.qitepinscience.org
+62 821 2345 0630 qitep_in_science QITEP in Science
@qitepinscience Qitep in Science